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(NASA-CR-135370) ANALYSIS AND TEST OF DEEP
FLAWS IN THIN SHEETS OF ALUMINUM AND
TITANIUM. VOLUME 2: CRACK OPENING
DISPLACEMENT AND STRESS-STRAIN DATA
Contractor (Boeing Aerospace Co., Seattle, G3/39

ANALYSIS AND TEST OF DEEP FLAWS IN THIN SHEETS OF ALUMINUM AND TITANIUM

VOLUME 2—CRACK OPENING DISPLACEMENT AND
STRESS-STRAIN DATA

By
R. W. Finger

THE BOEING AEROSPACE COMPANY

Prepared For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Lewis Research Center
Contract NAS3-19697
Gordon T. Smith, Project Manager



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16. Abstract This experiment program was undertaken to further investigate the crack growth behavior of deep flaws in thin sheets. The program was designed to supplement the work performed under contract NAS3-18906 "Proof Test Criteria for Thin Walled 2219 Aluminum Pressure Vessels." Static fracture tests were performed on surface flawed specimens of both the aluminum and titanium alloys. A simulated proof overload cycle was applied prior to all of the cyclic tests. Variables included in each test series were flaw shapes and thickness. Additionally, test temperature was a variable for the aluminum test series. The crack opening displacement and stress-strain data obtained is included in this report. The data analysis and exact specimen and flaw size dimensions are presented in Volume I - NASA CR-135369.					
17. Key Words (Suggested by Author(s)) Crack Opening Displacement Stress-Strain Cryogen 2219-T87 Aluminum 6Al-4V STA Titanium				18. Distribution Statement Unclassified Unlimited	
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FOREWORD

This report summarizes the crack opening displacement and stress strain data obtained from tests of both 2219-T87 aluminum and 6Al-4V STA titanium performed by the Boeing Aerospace Company from July, 1975 through December, 1977. The work was administered by Mr. Gordon T. Smith of the NASA-Lew. Research Center. The program was conducted originally by the Research and Engineering and finally by the Boeing Military Airplane Development Division of the Boeing Aerospace Company, Seattle, Washington, under the supervision of Mr. H. W. Klopfenstein (Research and Engineering Division) and Mr. D. E. Strand (Boeing Military Airplane Division). The Program Leader was originally Mr. J. N. Masters and finally Mr. T. E. Dunning. The Technical Leader was R. W. Finger. Mr. H. Lenhart and H. M. Olden provided testing engineering support, and G. Jensen produced the technical illustration and art work. This technical report is also released as Boeing Document D180-24613-2.

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INTRODUCTION

This report contains the crack opening displacement records obtained during the testing of both the center crack and surface flawed specimens and the extensometer and strain gage curves from the mechanical property characterization portion of the program. The remaining test data is summarized and discussed in CR-135369 (Reference 1).

The crack opening displacement records presented are reproductions of the actual traces. The specimen number is given on each plot so that the other detailed test information can be located in CR-135369. Peculiarities encountered during testing have been noted on the individual plots. Some general comments pertinent to a-1 of the plots are presented below:

The Crack Opening Displacement gage (COD) was reset after each load cycle;

The COD gage was spring loaded against integrally machined knife edges for all of the center crack panels and against gage brackets for all the surface flaw tests.

All of the center-crack panels were loaded directly to failure, therefore, all of the associated crack opening displacement records are for the fracture loading;

The surface flawed specimens were subjected to a variety of different loadings which are denoted on the plots.

The crack opening displacement records were used to calculate the constant " c_0 " in the following equation

$$\delta = c_0 \frac{\sigma a}{\sqrt{Q}}$$

where δ = crack opening displacement
 σ = gross area applied stress
 a = flaw depth
 Q = flaw shape parameter (presented in Figure 6 of NASA CR-135036).

Only the initial linear portion of the crack opening displacement records was considered in making these calculations. This was done to avoid the region of stable crack growth and to permit the initial crack dimension to be used. The calculated c_o values were compared to those presented in Appendix B of Reference 2. Reference 2 found that the calculated c_o value was dependent upon the ratio of flaw depth to specimen thickness (a/t) and the flaw shape ($a/2c$). Under the subject study three different flaw shapes were considered within a limit range of flaw depth to specimen thickness (a/t 's). The calculated c_o values from this report were in good agreement with the Reference 2 values. Additionally, the " c_o " values have been compared to a theoretical solution of Kobayashi (3). The agreement between the experimental values obtained in both this study and Reference 2 with the theoretical solution is quite good especially for flaw depth to thickness ratios in excess of 0.40.

The load-extensometer and load-steam gage curves generated during the mechanical property characterization portion of the program are presented in Appendix III. The extensometer curves were used in the calculation of the yield strength. A 50.8 mm (2.0 inch) gage length was used for all the extensometer tests.

The strain gage records have been identified as either axial strain gage or Poisson's strain gage. The axial strain gages were mounted on the specimen parallel to the loading direction and the Poisson's strain gages were oriented perpendicular to the loading direction. The strain gage results were used in the calculation of Poisson's ratio.

References:

1. R. W. Finger, "Analysis and Test of Deep Flaws in Thin Sheets of Aluminum and Titanium." Volume I NASA CR-135369, April 1978.
2. J. N. Masters, W. D. Bixler, R. W. Finger, "Fracture Characteristics of Structural Aerospace Alloys Containing Deep Surface Flaws." NASA CR-134587, December 1973.
3. A. S. Kobayashi, "Crack Opening Displacement in A Surface Flawed Plate Subjected to Tension or Plate Bending." Boeing Document D180-19446-1, February 1976.

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ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 1AR-1

227 69,200

64 —

56 —

48 —

40 —

32 —

24 —

16 —

8 —

0 — 1AR-1

REPRODUCIBILITY OF THE
ORIGINAL PAGE

0.001
INCH

STRAIN RATE
IN / IN / MIN
59,000

LOAD RATE
LBS / MIN

DEFLECTION
IN

0.004

TEST
CHECK
APPD
DATE
1-28-64

ALUMINUM CENTER CRACK PANEL
 CRACK OPENING DISPLACEMENT RECORD
 Specimen - IAR-2

72—
 64—
 56—
 48—
 40—
 32—
 24—
 16—
 8—
 0 IAR-2

LOAD (KIPs)

0.004
 INCH

ULT. 60,600

STRAIN RATE
 IN/IN MIN.
 1.000

LOAD RATE
 LBS./MIN.
 50,000

DEFLECTION
 IN.
 0.01

CALC. ——— OPS. ——— 1-27-6

CHECK ——— APPD. ———

BOEING TPR

ENR
 PAGE 07

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - TAR-3

112—

96—

80—

64—

48—

32—

16—

0—

LOAD (KIPS)

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

0.002
INCH

IAR-5

ULT. 99,000

STRAIN IN INCH	STRAIN RATE IN./IN./MIN	LOAD RATE KIP./MIN	DEFLECTION IN INCH
200	0.001	0.001	0.001

9-9-71 ST-08

CALC APPD

CHECK

ENDING TPN

PAGE 07

318-043

A 10001 30 C 7107

80—

72—

64—

56—

48—

40—

32—

24—

16—

8—

0. 1AR-4

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 1AR-4

ULT 75,000

0.004
INCH

LOAD (KIPS)

STRAIN RATE IN./IN./MIN. 0.004
LOAD RATE LBS./MIN. 2000
DEFLECTION IN. 0.004

CALC

QPR 55

7226

CHECK

APPC

BOEING

1000

1000

1000

1000

1000

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 1AR-5

ULT 112,000

128—

112—

96—

80—

64—

40—

32—

16—

0—

LOAD (KIPS)

0.005
INCH

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

LOAD RATE
100,000
100,000

STRAIN RATE
100,000
100,000

DISSECTION
100,000
100,000

CALC
CHK
APPD

CHECK

DATE
PAGE OF

118-500

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1AR-6

OLT 104,300

112

96

80

64

48

32

16

1AR-6

LOAD (KIPS)

0.005
INCH

STRAIN RATE
IN/IN MIN
100,000

LOAD RATE
IN/IN MIN
100,000

SELECTION
1005

CALC

CHECK

APPRO

DATE

BY

DF

318-007

318-007

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-1

28—

24—

20—

16—

12—

8—

4—

0—

LOAD (KIPS)

0.001
INCH

0.002
INCH

ULT 23,700

Changed Displacement
Scale

REPRODUCIBILITY OF THE
ORIGINAL PAGE

7AR-1

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN/SEC	LB/IN/SEC	IN

002
20,000
002

CALC ———— ODB ———— APPC ————
CHECK ————

EDDING

118-007

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-2

32—

28—

24—

20—

16—

12—

8—

4—

0 7AR-2

LOAD (KIPS)

0.004
INCH

ULT. 28,800

STRAIN RATE
IN./IN./MIN
LOAD RATE
LBS./MIN
DEFLECTION
IN.

0.004

25,000

1.22-6

CALC

CPB

35

CHECK

APPD

SIDING

104

PAGE

OF

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 7AR-3

ULT 30,000

32

LOAD (KIPS)

28

24

20

16

12

8

4

0 7AR-3

REPRODUCIBILITY OF THE
ORIGINAL PAGE

0.004
INCH

DEFLECTOR

LOAD RATE
125 /MIN

STRAIN RATE
10 /IN /MIN

STRAIN
IN /IN

.004

30,000

1-27-6

OPR

CHECK

APPRO

13
PAGE OF

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-4

48—

LOAD (KIPS)

40—

32—

24—

16—

8—

7AR-4

0.002
INCH

ULT. 42,000

STRAIN IN IN.	STRAIN RATE IN./IN./MIN.	LOAD RATE LBS./MIN.	DEFLECTION IN.
		42,000	.002

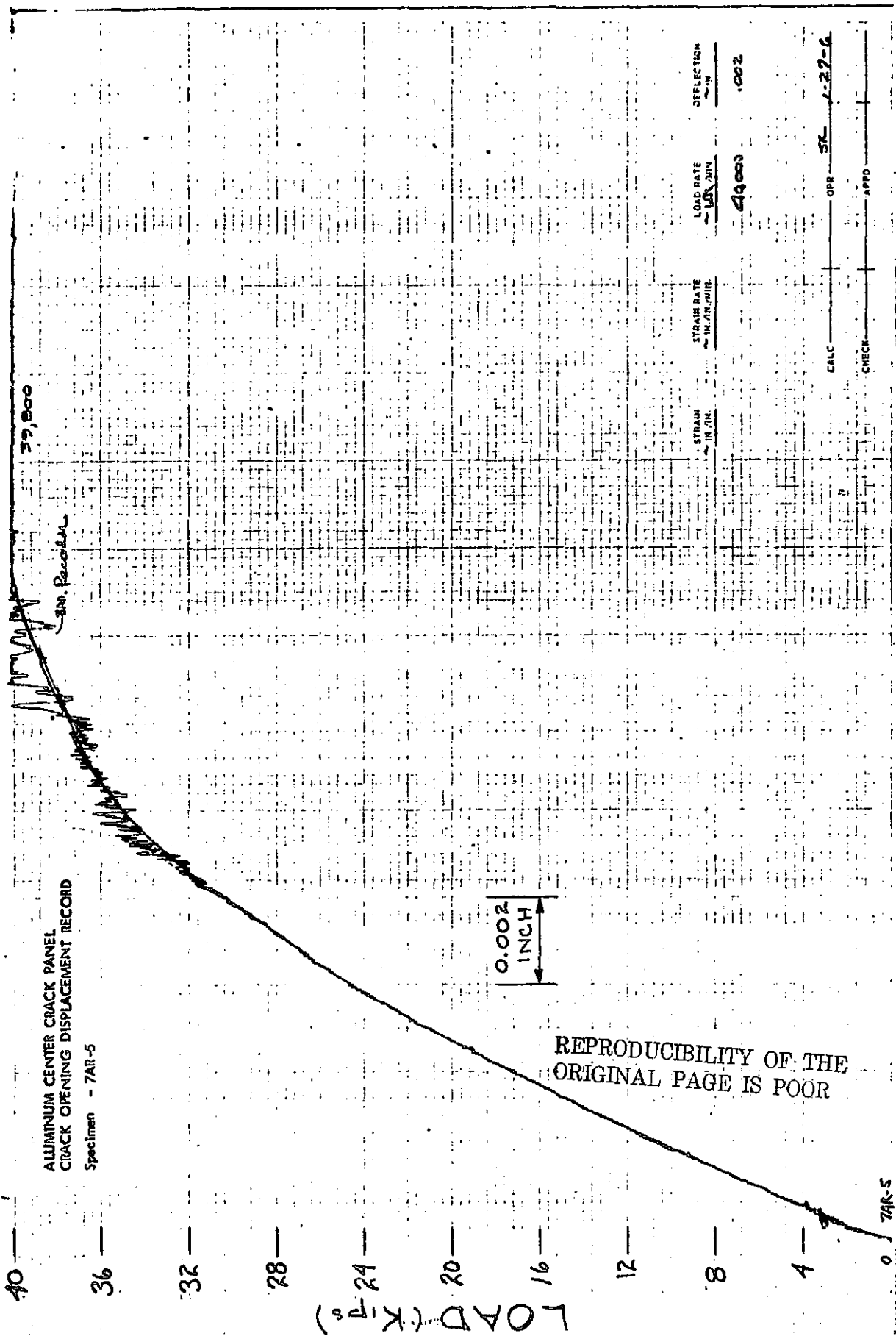
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CHECK ————

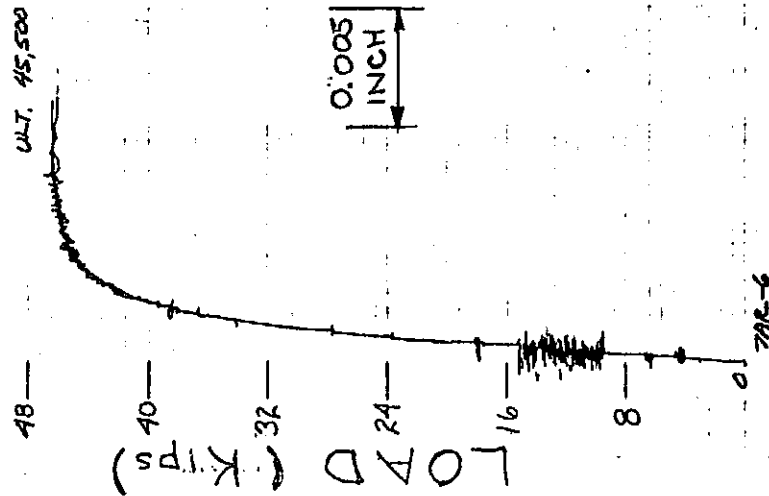
BOEING TPR

J18-007

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ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-6

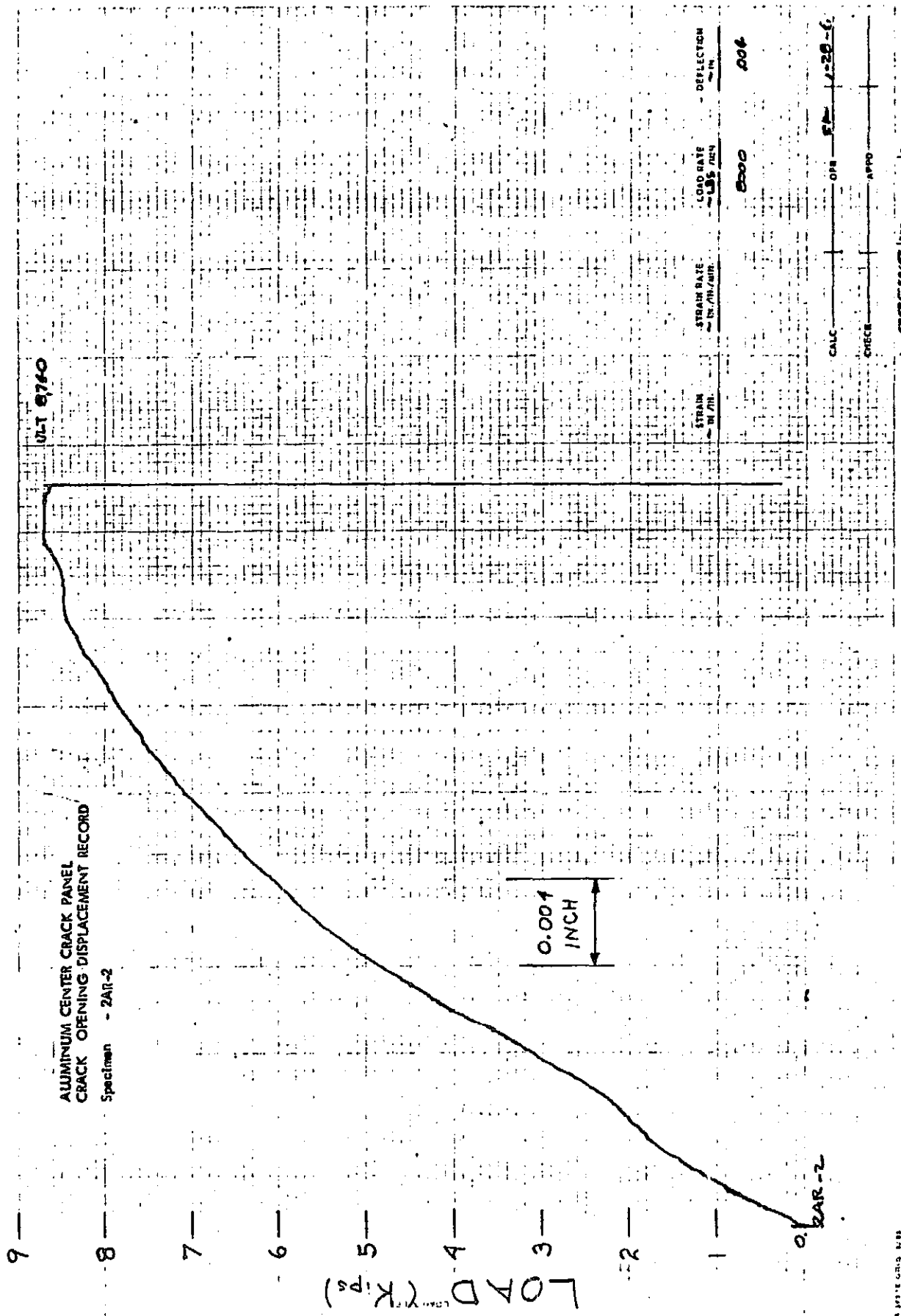


STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE PSI/IN	DEFLECTION IN
		5000	0.005

CALC. QPR 5/11 12-26-6

CHECK APPD

BIDENING 100R 5.00 PAGE 07



ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR-3

14—

12—

LOAD (K_f)

10—

8—

6—

4—

2—

0 2AR-3

ULT 12,520

Crack Opening Displacement
Gage Failed

0.004
INCH

STEADY RATE
IN./MIN.
1000

LOAD RATE
IN./MIN.
1000

DEFLECTION
IN.
0.01

CALC. OPB. APPD. 1-28-6

CHECK

NOTE ON S. 8048

319-047

DRIVING

1044
PAGE 00

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR-4

LOAD (KIPS) 20—
16—
12—
8—
4—
0/2AR-4

ULT 15.600

0.004
INCH

STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE LBS/MIN	DEFLECTION IN
		15,000	.004

CALC ——— OP2 ——— 1-28-6
CHECK ——— APPD ———
BOEING

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - ZAR-5

VI-7 13.650

LOAD (KIPS)

0.004
INCH

ZAR-5

STRAIN
~ IN/IN

STRAIN RATE
~ IN/IN/MIN.

LOAD RATE
~ LBS./MIN.

DEFLECTION
~ IN.

000

13000

CALC _____

CHECK _____

APPRO _____

OPER _____

13000

11111 000 000

BOEING

PAGE 01

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

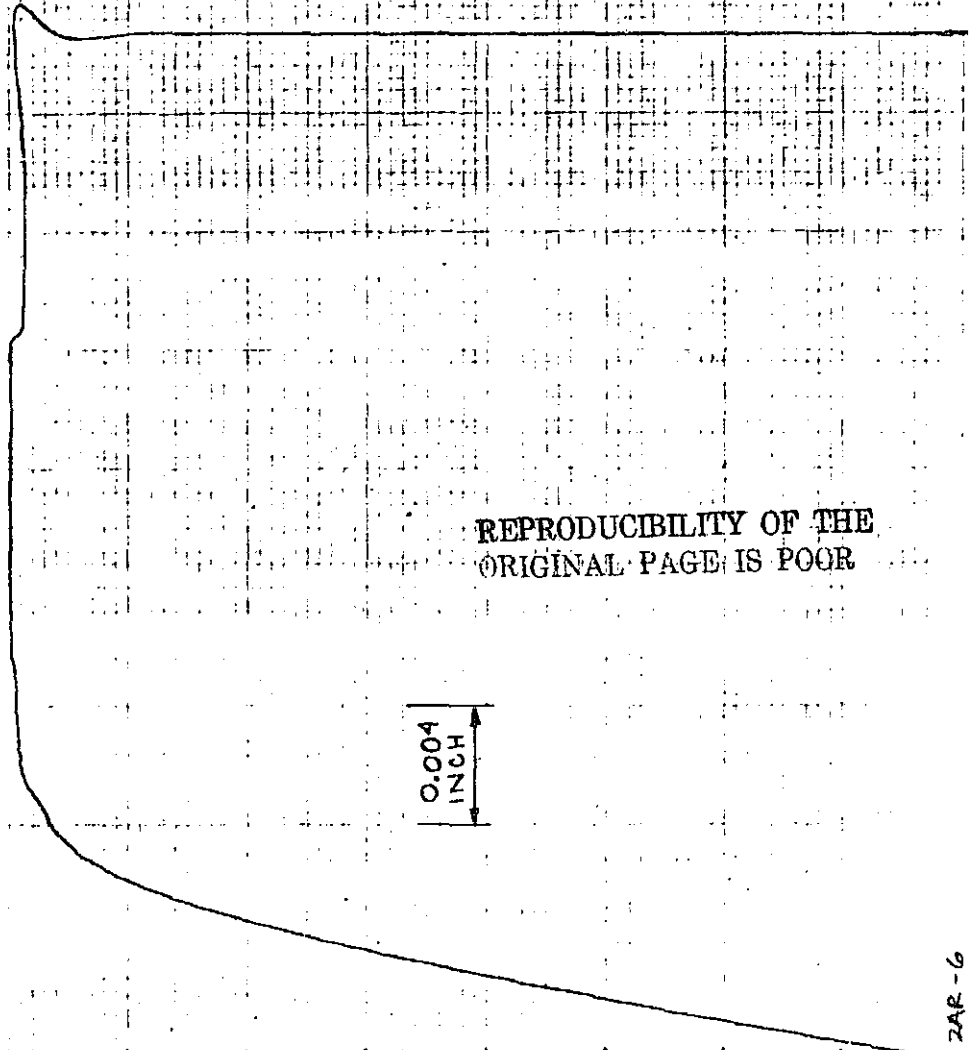
Specimen - 2AR-6

ULT = 16,000

18 —
16 —
14 —
12 —
10 —
8 —
6 —
4 —
2 —
0

LOAD (K-PS)

0.004
INCH



REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

STRAIN RATE
IN/IN/MIN
15,000

LOAD RATE
2500

DEFLECTION
IN

0.04

CALC ———— OPN ———— 56 ———— 1-28-6

CHECK ———— APPD ————

0 2AR-6

J16-047

BEING TPR

SEA

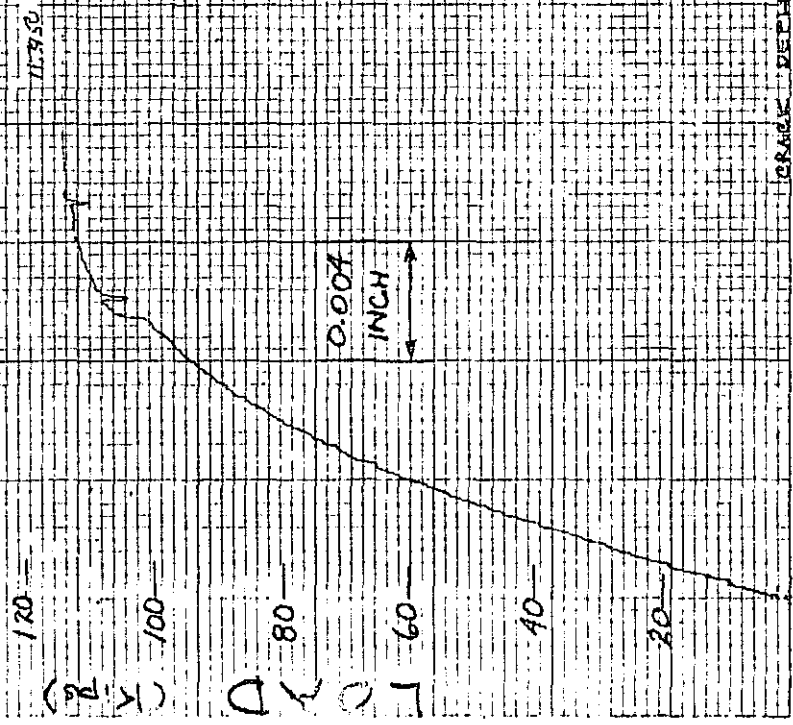
PAGE

OF

TRACK DEFLECTOR - 1004 IN/IN

ALUMINUM CENTER CRACK PANEL CRACK OPENING DISPLACEMENT RECORD

Specimen - 1AH-2



SPECIMEN 1AH-2
LOAD TO FAILURE AT 425°F
TOLANIS 2-1-76

CRACK DEFLECTION IN INCH

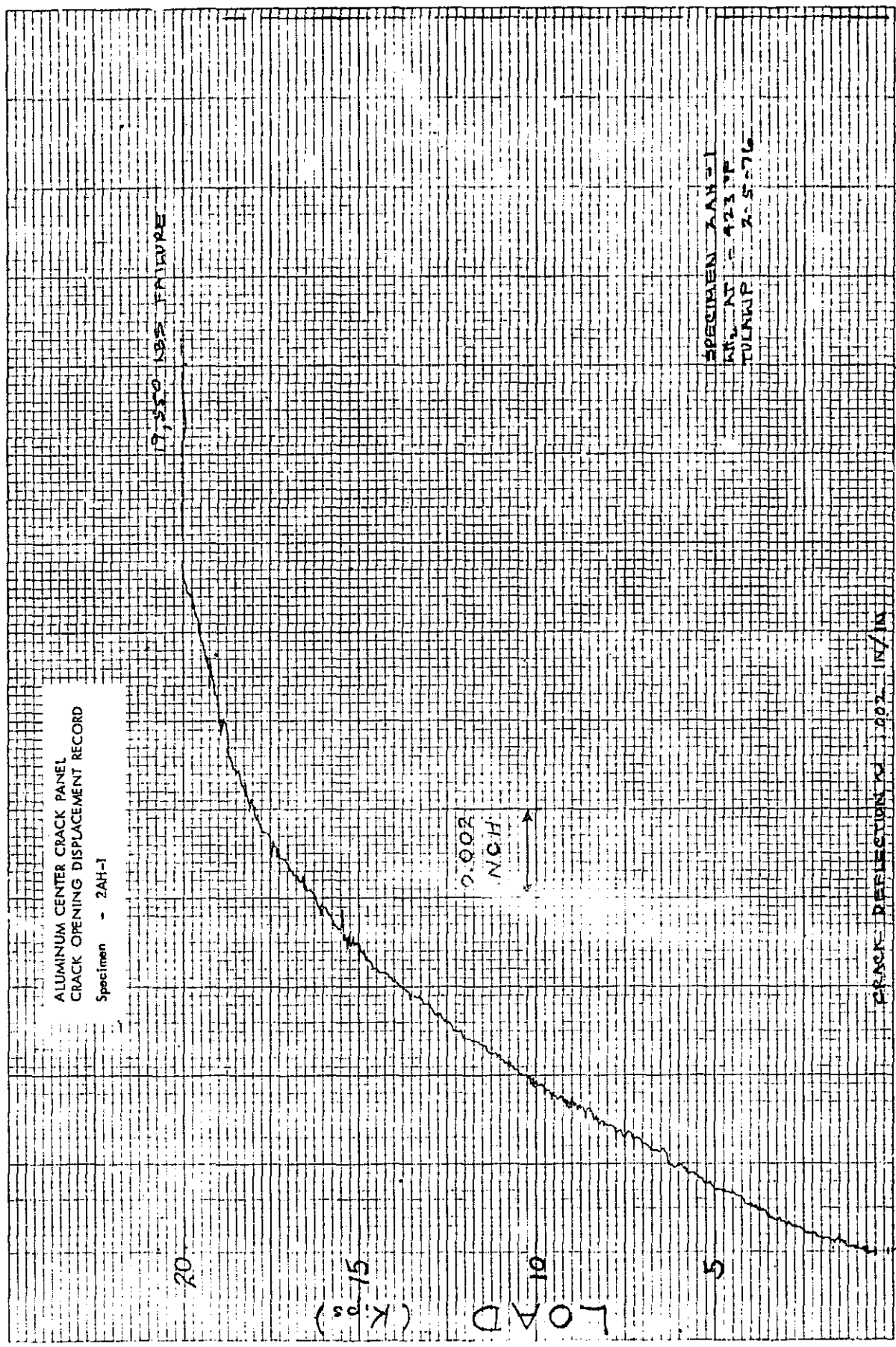
Specimen - 7AH-2

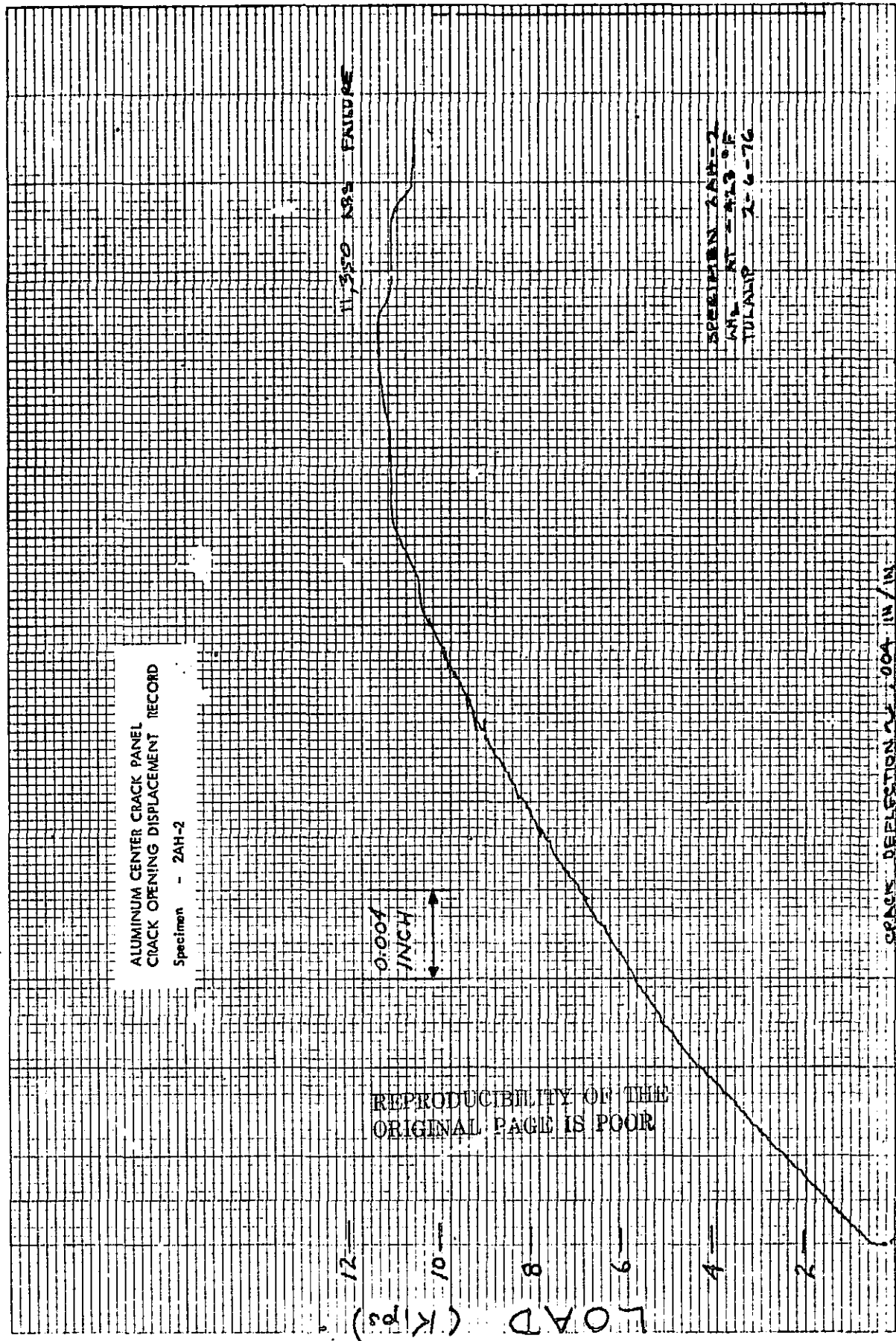


0.004 INCH

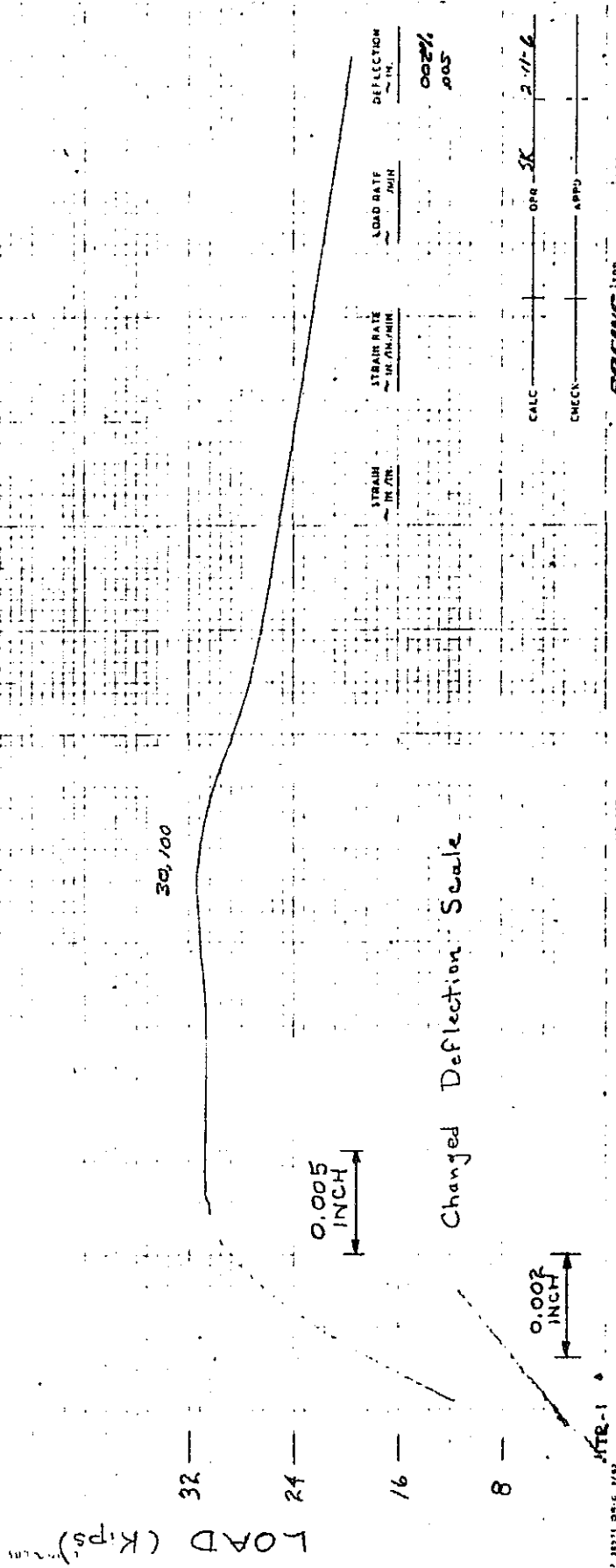
SPECIMEN	7A47-2
LEAD TO FAILURE AT	2473.0 F
TOTAL TIME	2-3-76

CRACK DEPTH ~ .004 in/in





TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1TR-1



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1Tr-2

LOAD (KIP)

32—

24—

16—

8—

17R-2

20,900

0.005
INCH

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

DEFLECTION

LOAD RATE /MIN

STRAIN RATE /IN./IN./MIN

STRAIN /IN./IN.

3-11-6

OPR SL

CHECK

APPO

EMA

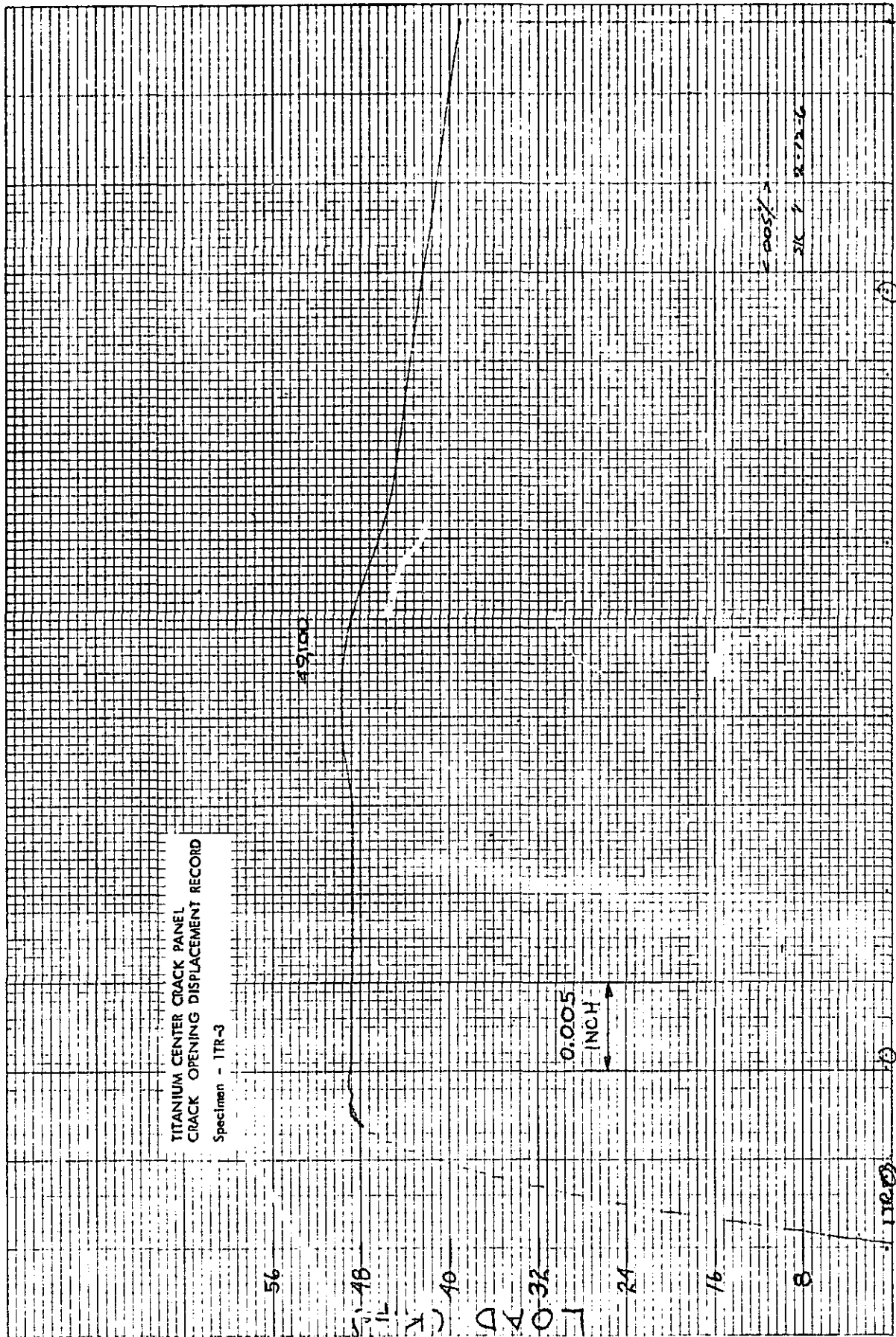
TPR

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OF

218-087

4-1172 ON 6 1975



ITR-3

11-10-70

11-10-70

11-10-70

11-10-70

11-10-70

11-10-70

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11-10-70

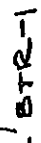
11-10-70

11-10-70

11-10-70

11-10-70

Specimen - 8TR-1



REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

0.005
INCH

-005-

DATE

STRAIN RATE:

NOTES

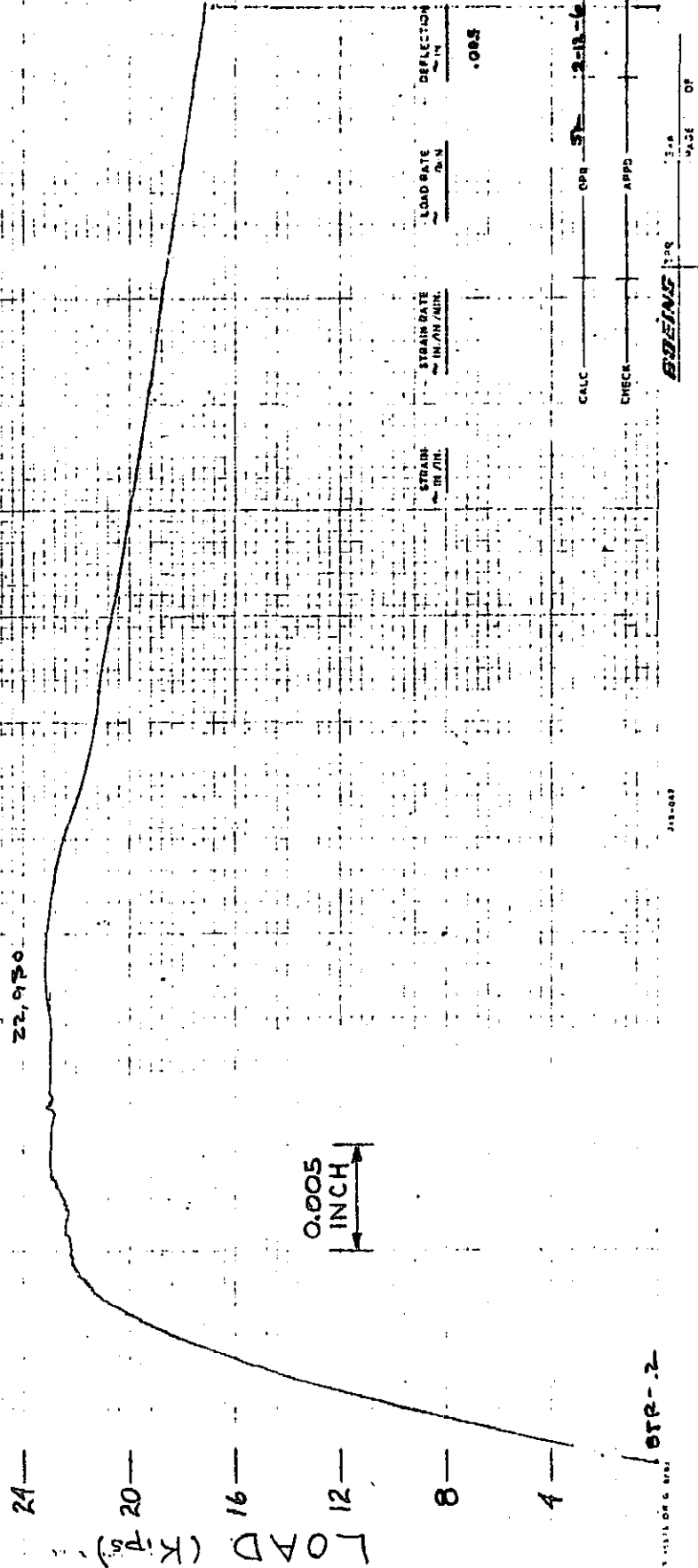
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—ДЛЯ

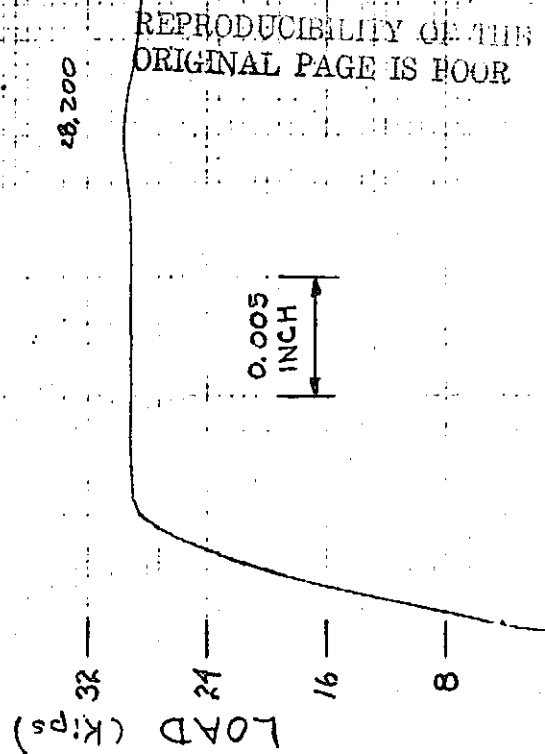
ANSWER

B41

for:



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 8TR-3



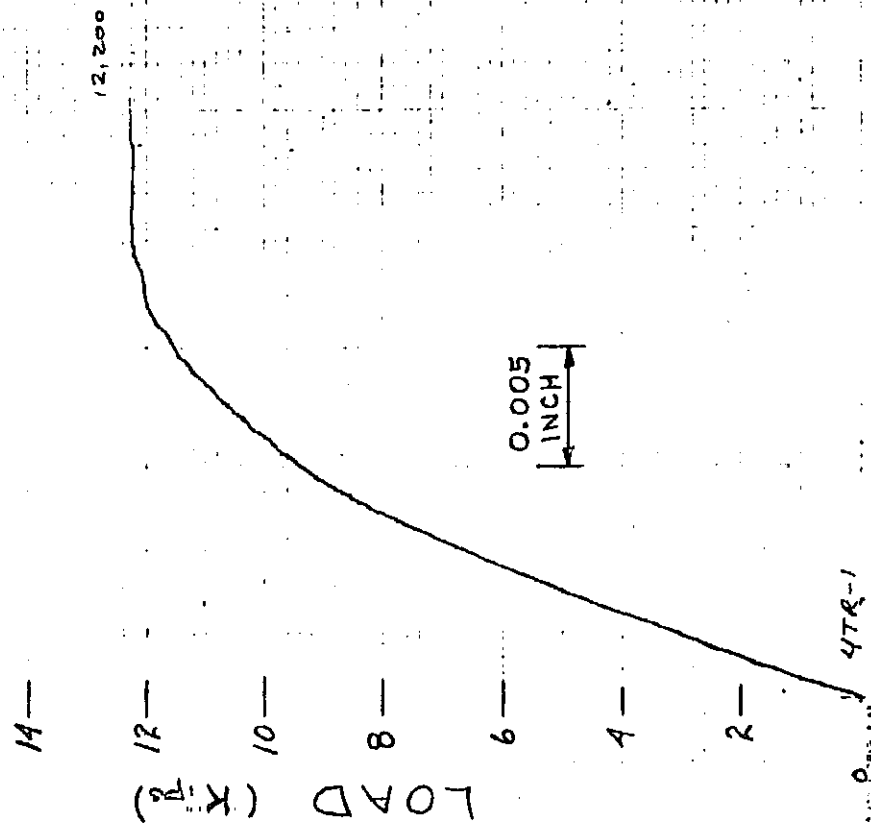
STRAIN RATE $\frac{in}{in}/min.$ LOAD RATE $\frac{lb}{in}/min.$ SELECTION ON

CALC. CDR. 5K 208-6

CHECK APPD.

DOING TPO PAGE OF

TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 4TR-1

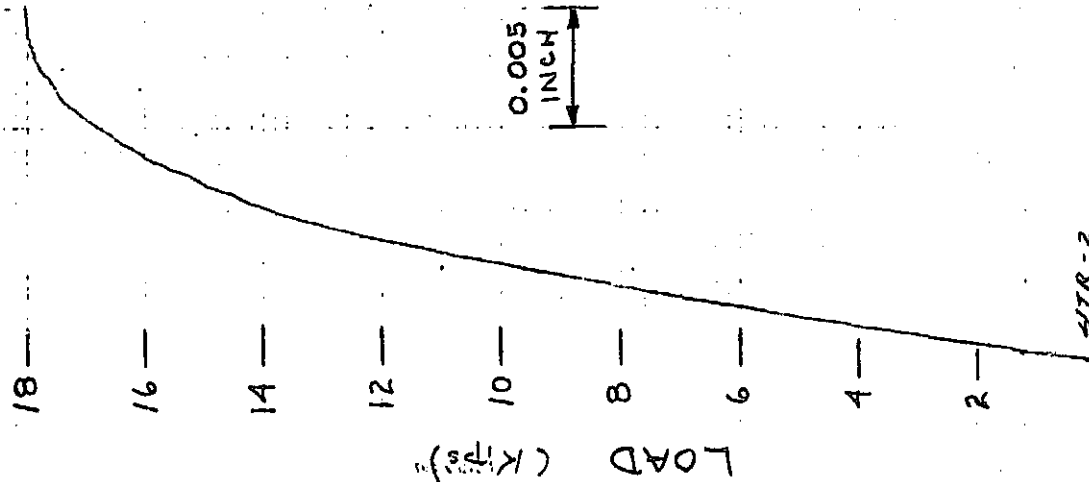


STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN/MIN	LBS/IN	IN
			0.005

CALC _____ OBS PCT 12-29-76
CHECK _____ APPD _____

BUENING

18,000



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 4TR-2

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS 100%

DEFLECTION
IN INCHES
0.005

LOAD RATE
IN INCHES
0.005

STRAIN RATE
IN INCHES
0.005

STRAIN
IN INCHES
0.005

OPR PCT 2-23-76

CALC

CHECK APPD

4TR-2

35

Graph showing Load (KIPS) versus Displacement (INCHES) for specimen 47E-3. The load increases to a peak of 12.750 KIPS at a displacement of approximately 1.5 inches, then decreases. A vertical scale bar indicates 0.005 INCH.

STRAIN RATE	LOAD RATE	DISPLACEMENT
IN/IN/SEC	IN/IN	IN
CALC	0.00	RET 2-23-75
CHECK	APPD	
BENDING		TESTED
PAGE		OF

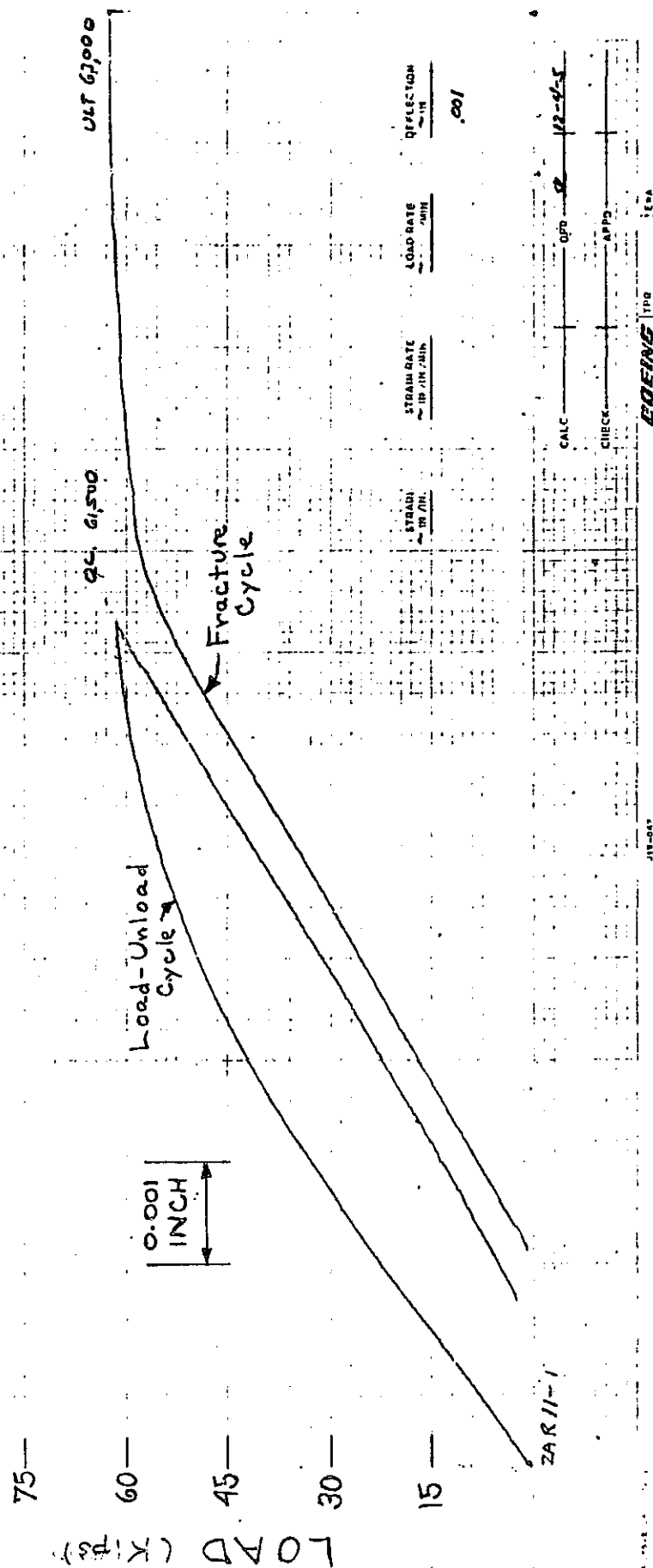
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Opening Displacement Records**

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Opening Displacement Records

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39

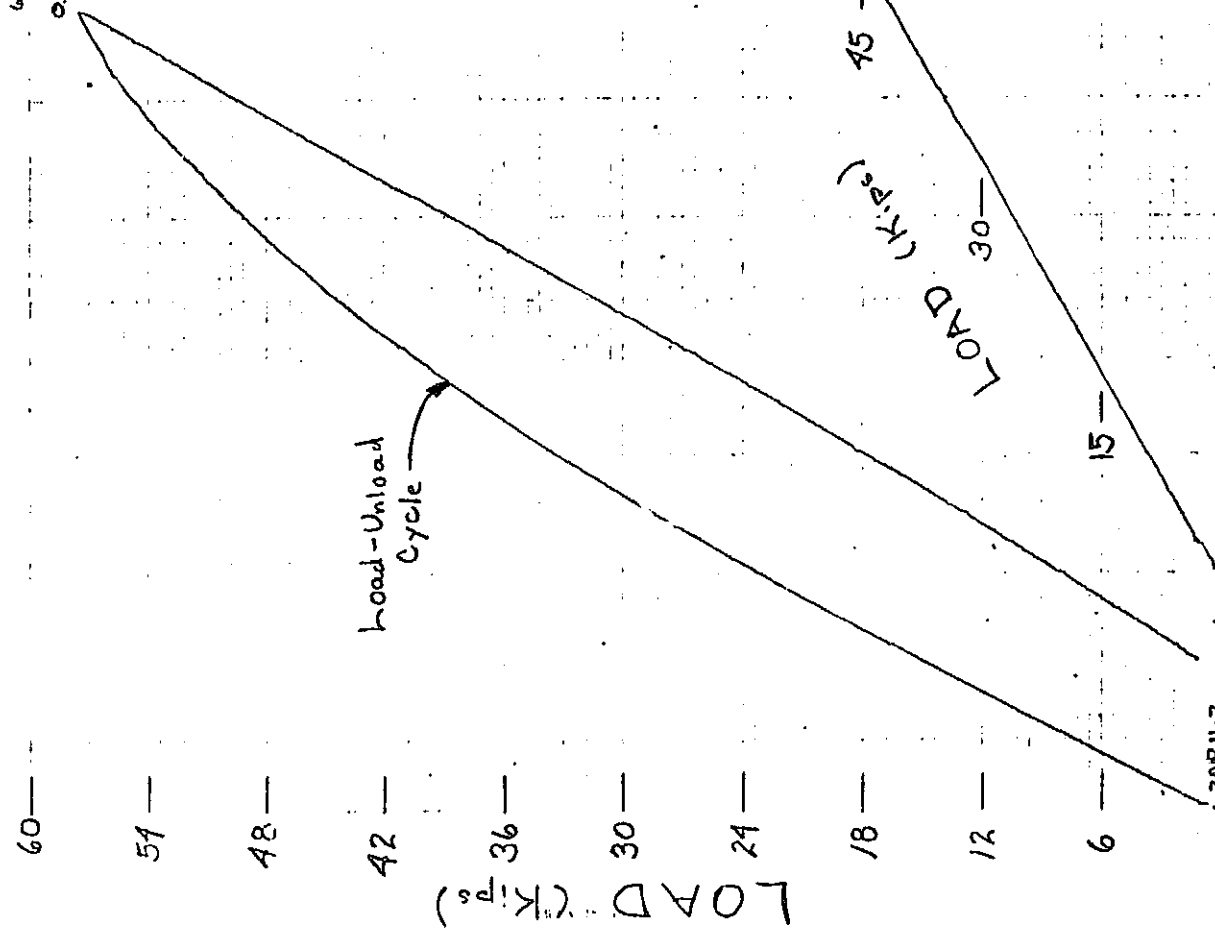


60 KIPS
OL 57,437

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR11-2

0.001
INCH

150 KIPS
OLT 22,400



2AR11-2

STRAIN RATE
IN/IN MIN
LOAD RATE
MIN
DEFLECTION
IN

CALC
CHK
APPD
12-E-S

BOEING TPR
PAGE 01

0 a.c. 51,000

Load-Unload
Cycle

0.001
INCH

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR11-3

0 a.c. 58,500

Load-Unload
Cycle

LOAD (KIPS)

54—
48—
42—
36—
30—
24—
18—
12—
6—

Load (KIPS)
45—
30—
15—

STRAIN RATE
IN/IN MIN.

LOAD RATE
KIP/IN

DEFLECTION
IN/IN

0.001

CALC. CPG 51 15-9-5

CHECK. CPG 51 15-9-5

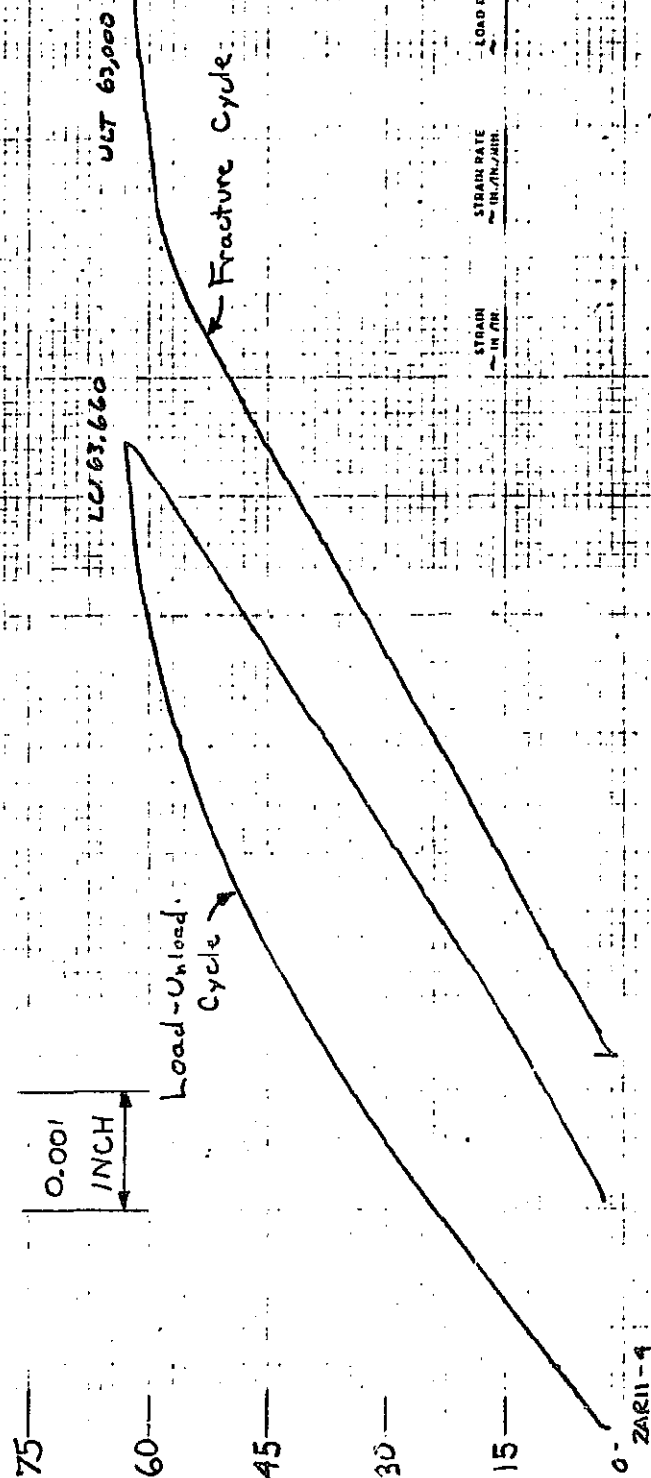
BOEING

PR

15-9-5

07

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR11-4



STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN/MIN	LB/IN	IN
			0.001

CALC _____ OPER _____
CHECK _____ APPD _____

LOAD (KIPs)

75—
60—
45—
30—
15—

3AR11-1

0.001
INCH

Fracture
Cycle

ULT 63150

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR11-1

STRAIN RATE
IN/IN/MIN
LOAD RATE
/MIN
DEFLECTION
IN
.001

CALC SK 12-9-55
CHECK APPD

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR11-2

75—

60—

45—

30—

15—

0

LOAD (KIPS)

0.001
INCH

0.00063700

Load - Unload
cycle

3AR 11-2

STRAIN RATE
IN/IN MIN

LOAD RATE
MIN

DEFLECTION
IN

.001

CALC

CHECK

OPR

APPRO

12-9-5

318-302

BOEING

PAGE

OF

1 MAY 1954

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR11-2

ULT 50,820

Fracture
Cycle

0.001
INCH

LOAD (K)

54

48

42

36

30

24

18

12

6

3AR 11-2

10-10-63

10-10-63

STRAIN
IN/IN

STRAIN RATE
IN/IN/MIN

LOAD RATE
LBS/IN

DISSECTION
IN

.001

CALC

CHECK

APPRO

BOEING

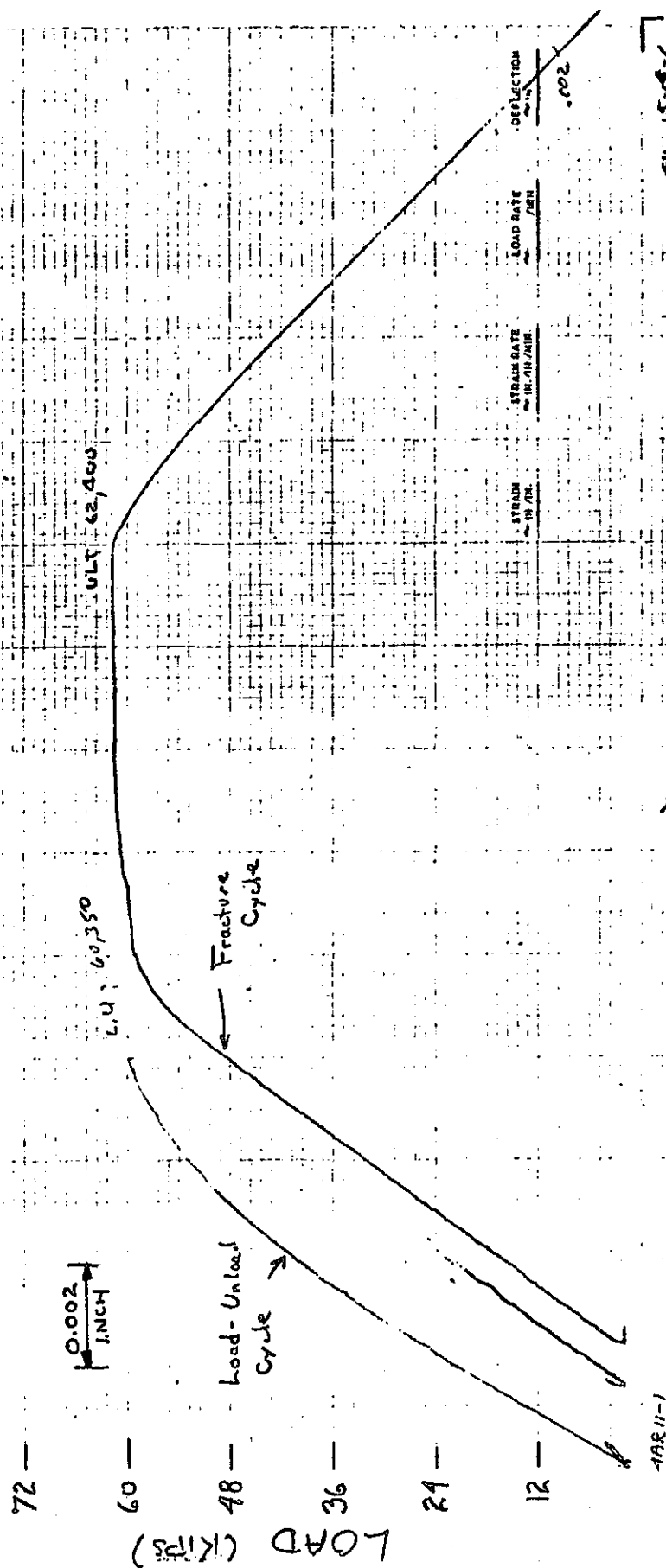
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DATE

BY

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 4AR11-1



4AR11-1

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR11-2

0.002
INCH

72

60

48

36

24

12

Load-Unload
Cycle

Fracture
Cycle

LU 60,600

UL 62,900

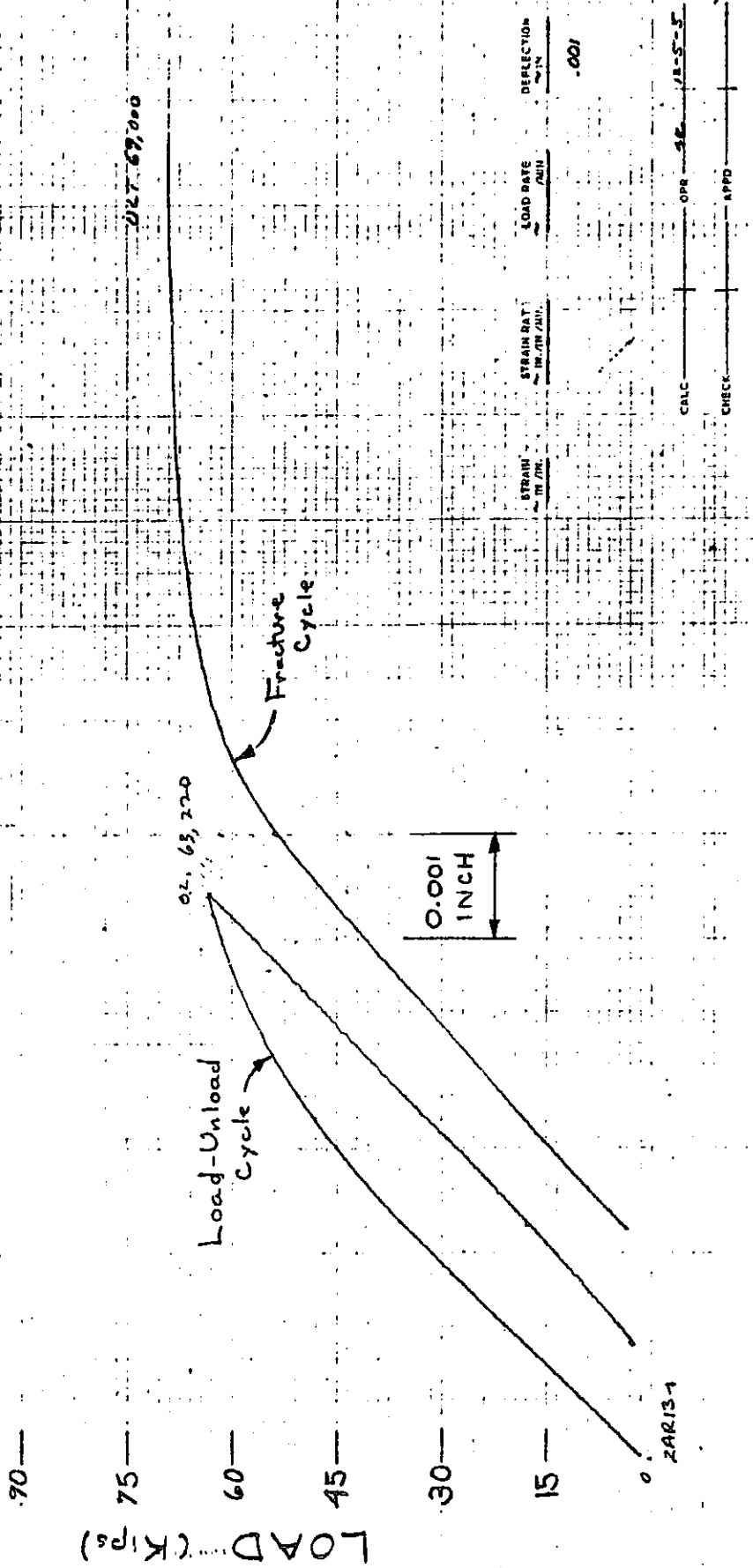
STRAIN RATE
IN/IN-MIN
LOAD RATE
LBS/IN
DEFLECTION
IN

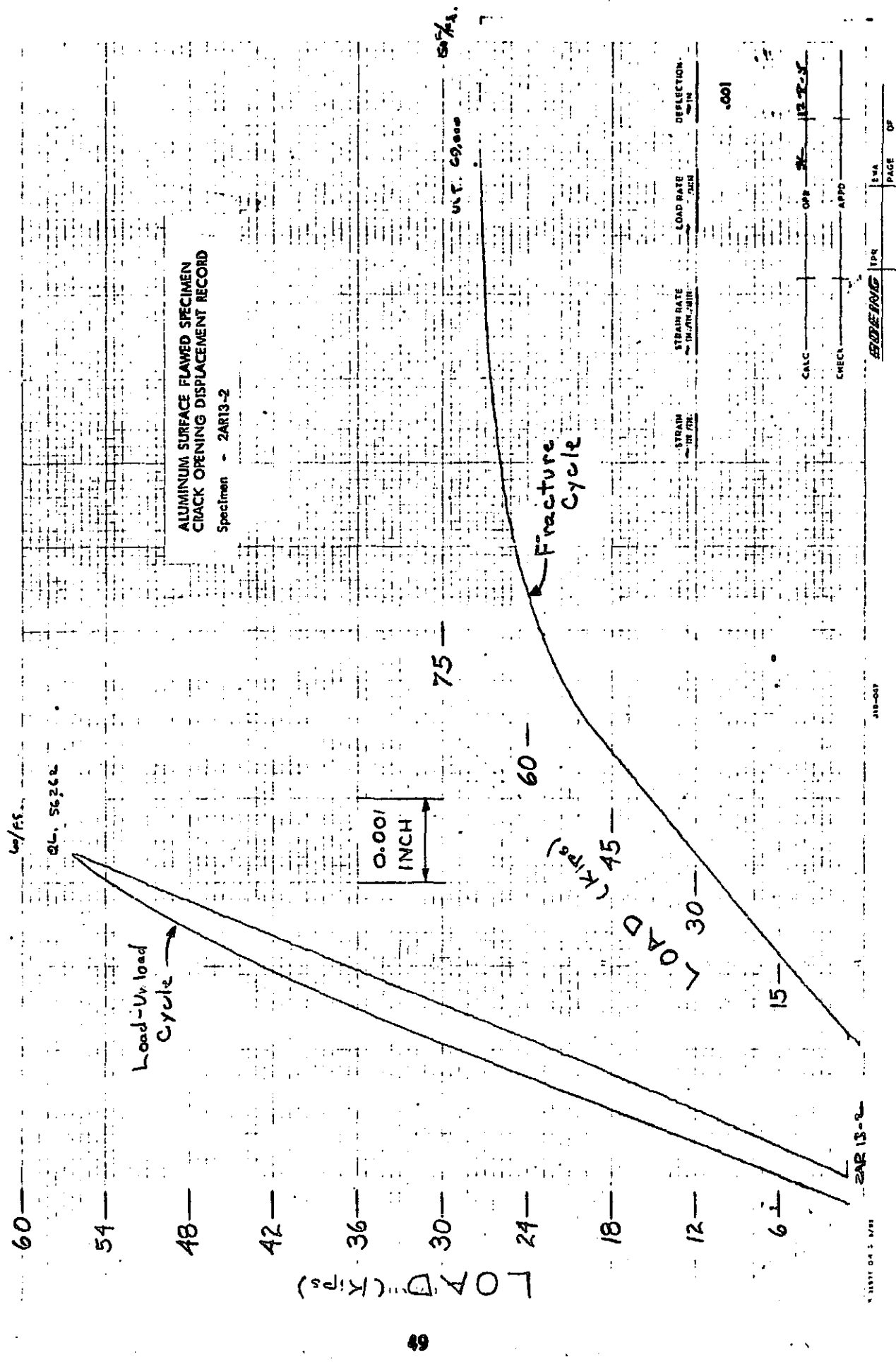
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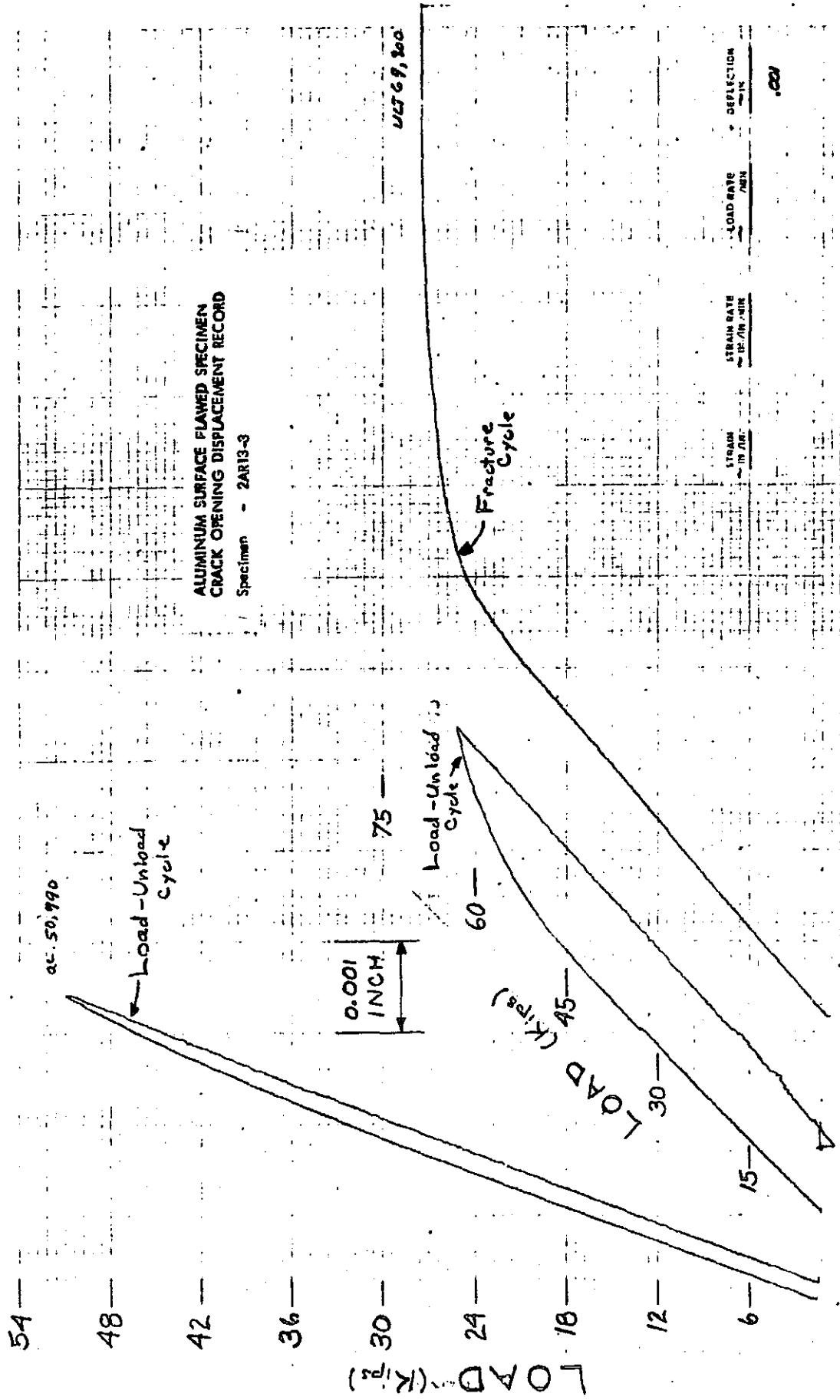
4AR11-2

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR13-1







ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2A13-3

AL-50,990

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN	IN/IN	IN

CALC — OPR — 42 — 12-10-5

CHECK — APPD —

BOEING

JIS-047

AL-50,990

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2A13-4

LOAD (KIP)

75

60

45

30

15

0.001
INCH

Load-Unload
Cycle

MS BT
66,880 LBS

ULT 69,000

Fracture
Cycle

STRAIN
IN/IN

STRAIN RATE
IN/IN/MIN

LOAD RATE
KIP

DEFLECTION
IN

.001

CALC

CHECK

0.002 2A13-4

110-007

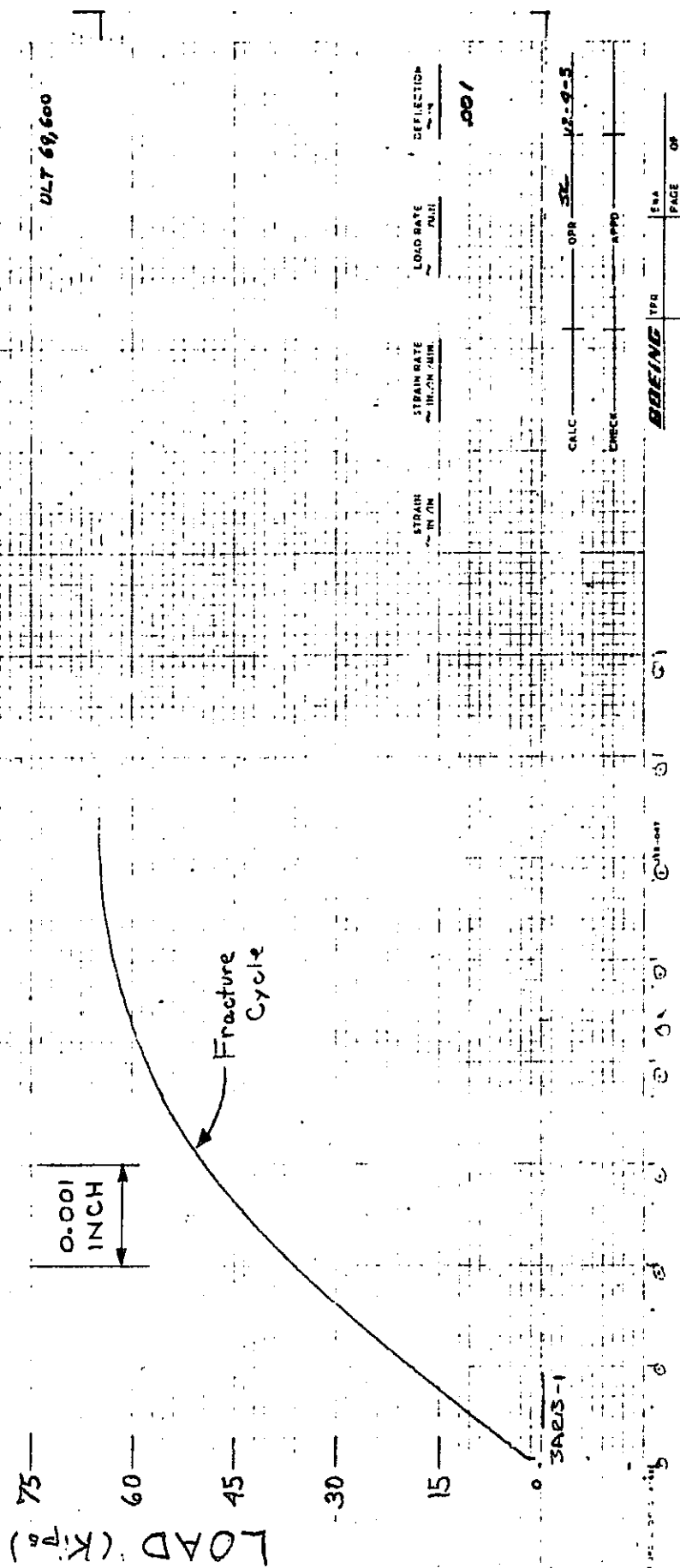
DATE 10/10/67

PAGE

OF

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3A13-1



LOAD (KIPS)

90—
75—
60—
45—
30—
15—

0.001
INCH

Load-Unload
Cycle

AL. BT. 69,600

UT 67,650

Fracture
Cycle

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR13-2

3AR 13-2

10-10-67

STRAIN RATE
IN./IN./MIN.

LOAD RATE
KIP/IN.

DEFLECTION
IN.

13-8-5

QPD

CALC

CHECK

APPD

ENGINE

PAGE

53

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2ART4-1

LOAD (KIPS)

90—
75—
60—
45—
30—
15—

0.001
INCH

21,250

Load-Unload
Cycle

Fracture
Cycle

STRAIN
IN/IN.

STRAIN RATE
IN/IN./MIN.

LOAD RATE
KIP/IN.

DEFLECTION
IN

.001

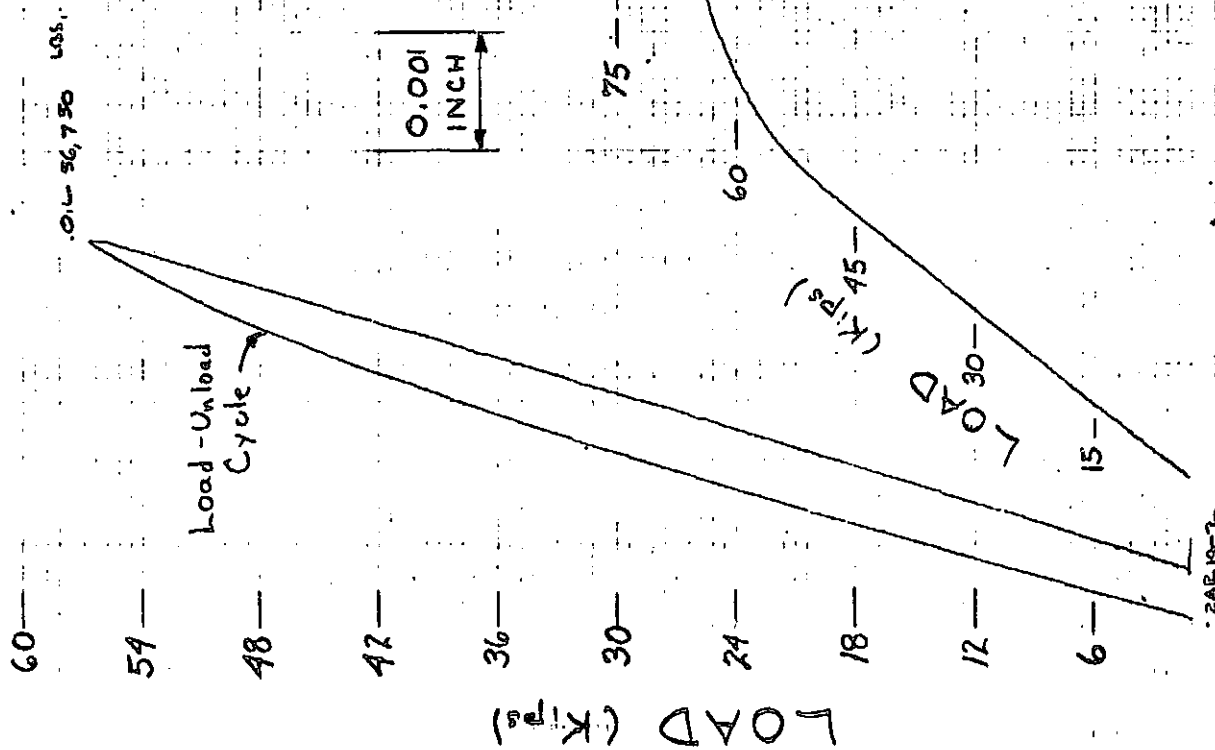
CALC. OPR. 92 21-2-8

CHECK. APPD.

JIS-047

BOEING TPR

PAGE 01



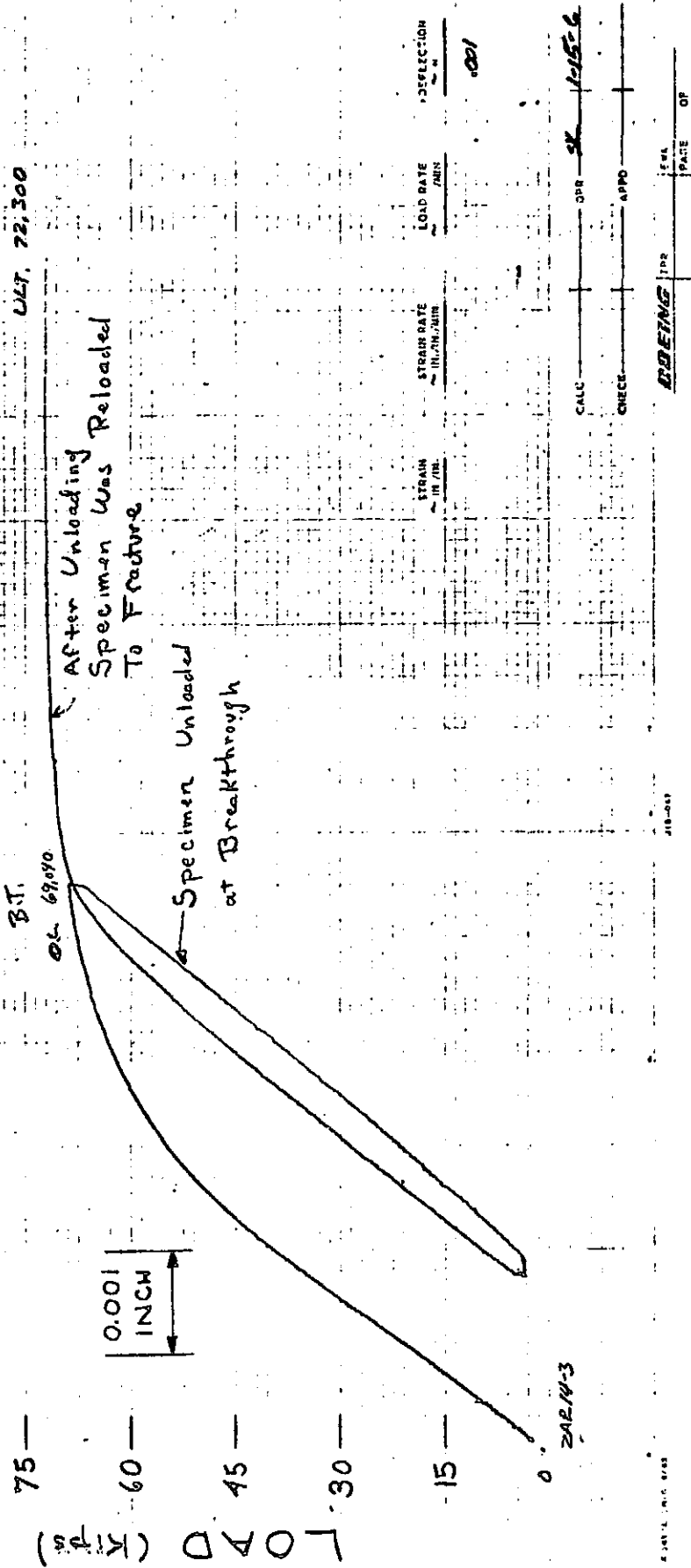
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR14-2

STRAIN RATE IN./IN./MIN	LOAD RATE K/IN	DEFLECTION IN
---	---	---

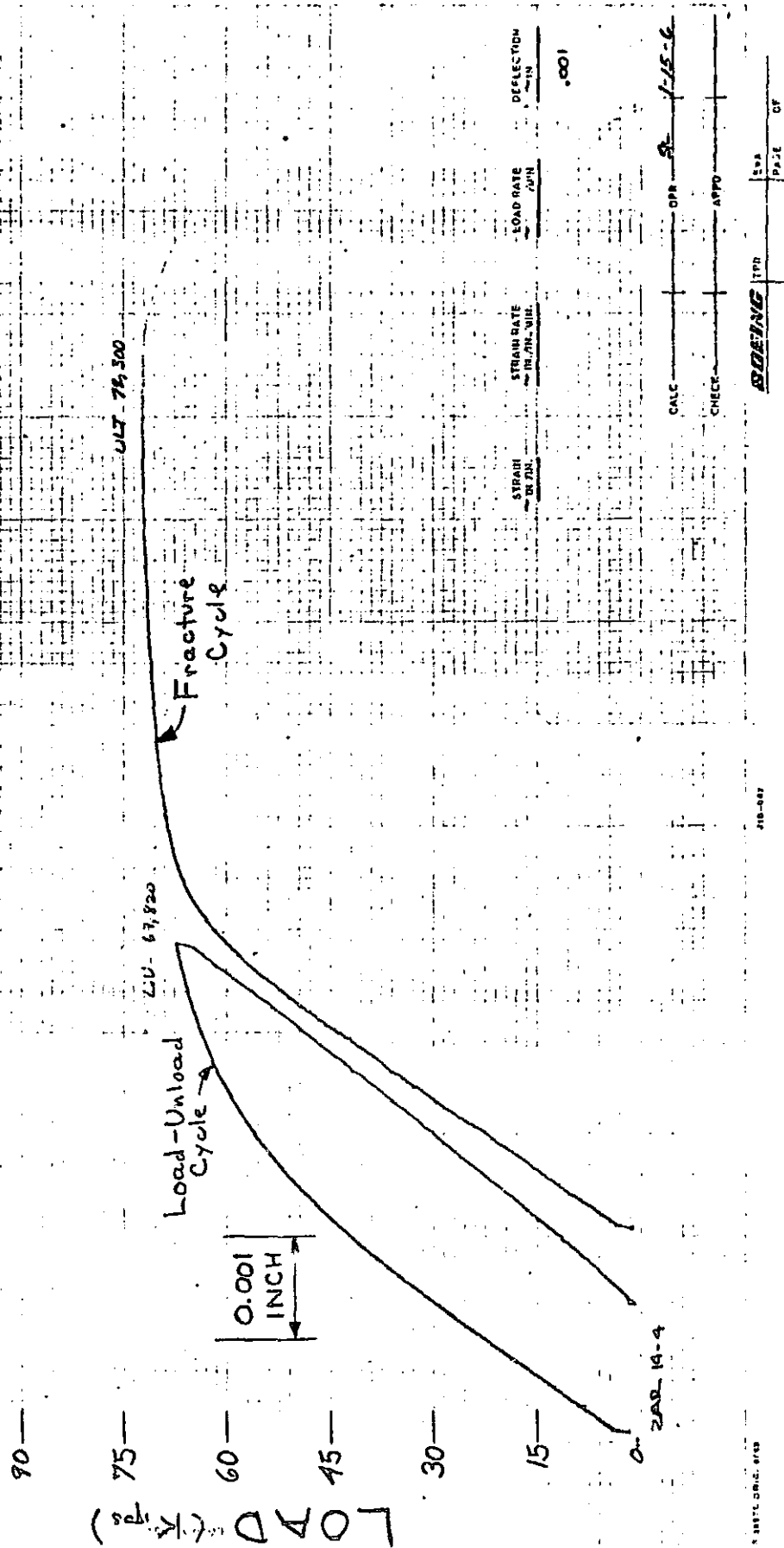
CALC	OPR	12-10-55
CHECK	APPRO	---

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR14-3



ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2A14-4



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR14-1

LOAD (Kips)
90—
75—
60—
45—
30—
15—

OUT 74,250

AS = 72,500

0.001
INCH

Fracture
Cycle

3AR14-1

STRAIN
— IN/IN

STRAIN RATE
— IN/IN/MIN.

LOAD RATE
— LBS/IN

DEFLECTION
— IN

0.001

CALC — OFR — 12-10-5

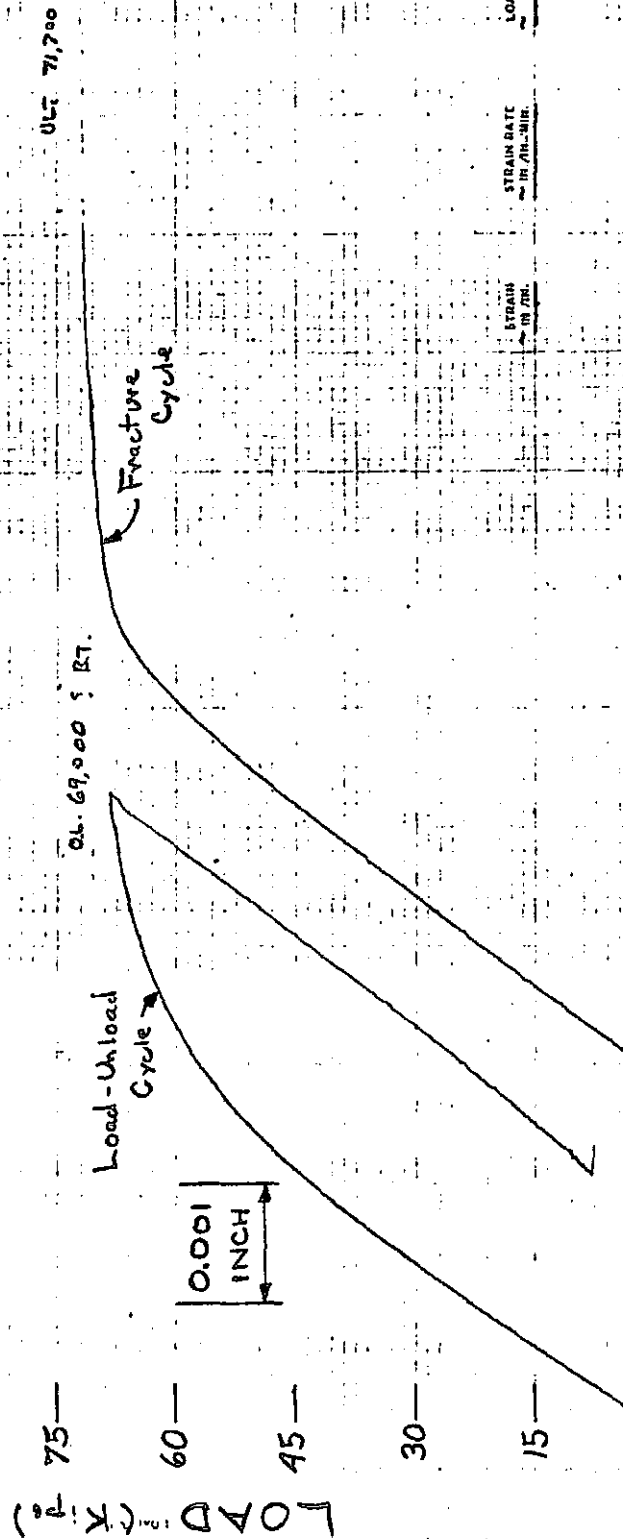
CHECK — APPD —

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318-007

8000-50-5-000

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR14-2



STRAIN RATE
IN./IN.-MIN.

LOAD RATE
MIN

DEFLECTION
INCH

.001

CALC

DPB

SE

12-10-5

CHECK

PPD

BOEING

178

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of

JUL-60

10-10-10

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen 4AR14-1

ULT 71,760

L.U. 66,106

P.T. 66,840

Fracture
Cycle

Load-Unload
Cycle

0.002
INCH

72

60

48

36

24

12

0

4AR14-1

LOAD (KIPS)

STRAIN RATE
IN/IN/MIN.

LOAD RATE
KIP/MIN.

DEFLECT
IN

CALC. QPR. 5/17-6

CHECK. APPD.

DATE 5-17-66

118-007

5-17-66 2:00 PM

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR14-2

ULT 73,200

L.U. 67,500

Load-Unload
Cycle

Fracture
Cycle

0.002
INCH

72 —
60 —
48 —
36 —
24 —
12 —
LOAD
(KIPS)

0-4AR14-2

.002

DEFLECTION

LOAD RATE

STRAIN RATE

STRAIN

5-17-66

SE

OPR

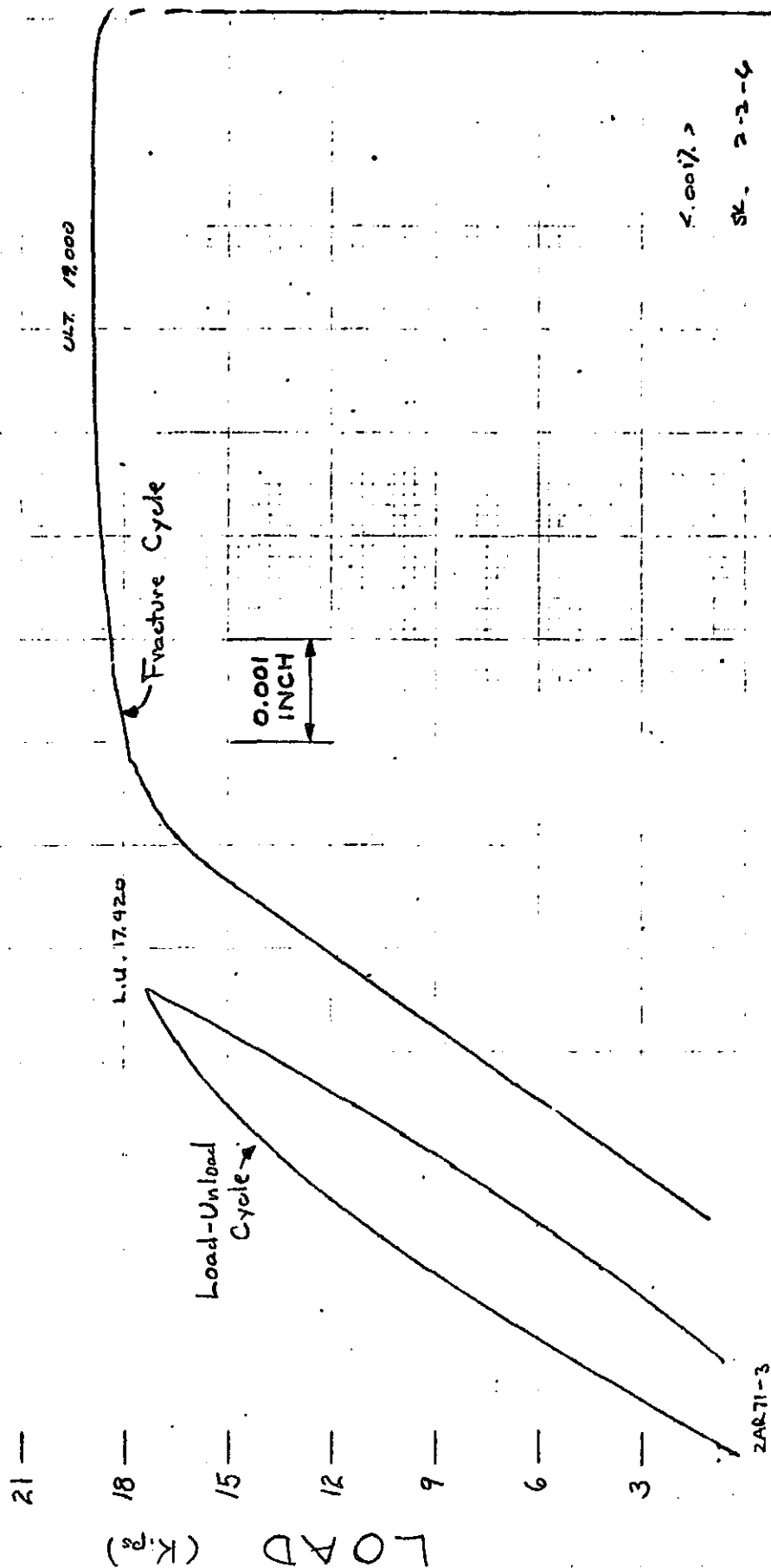
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APPR

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR71-3

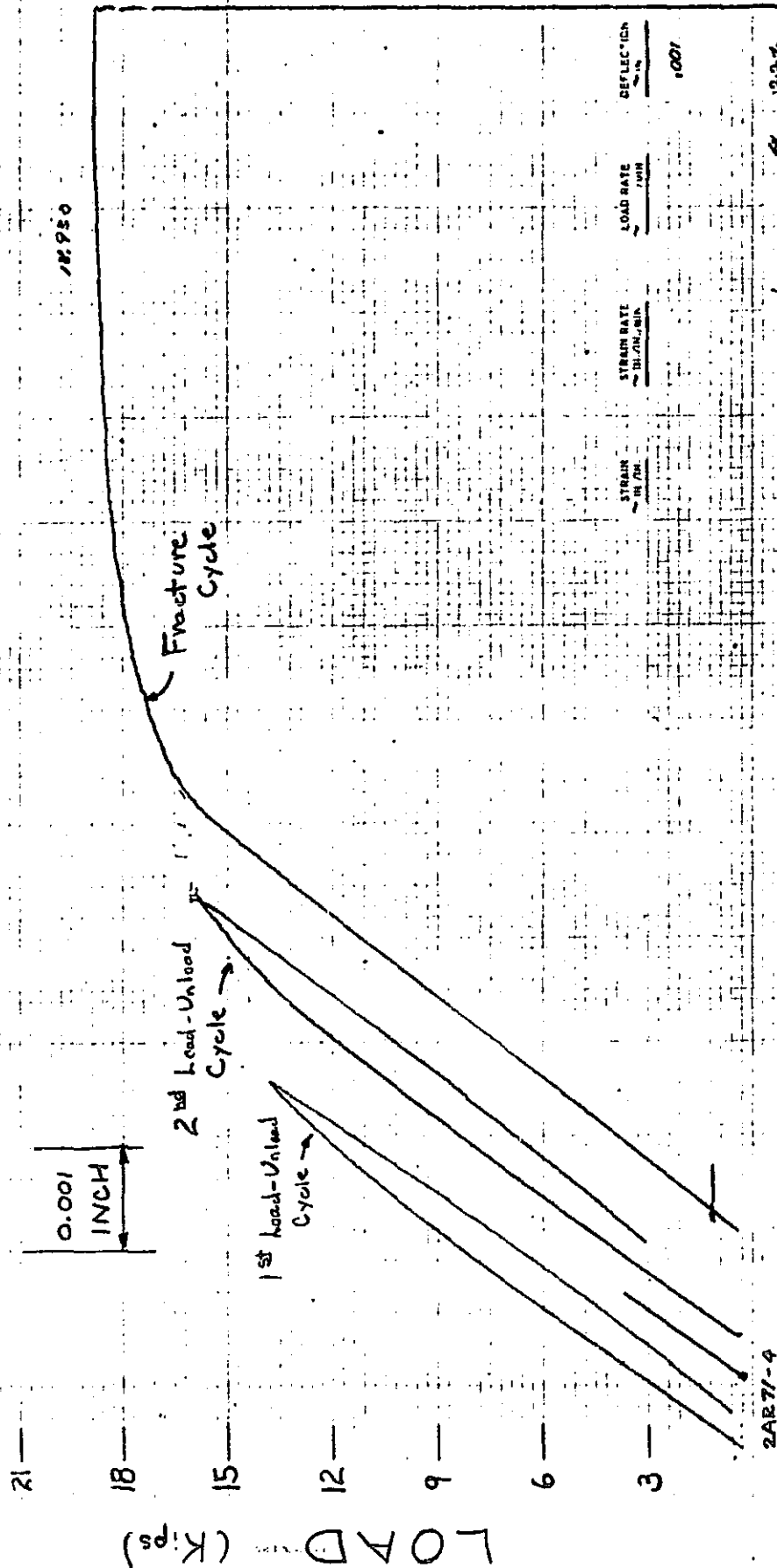


2.0017

SL. 2-2-4

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2A871-4



2.2

0.001

DEFLECTION

LOAD RATE

STRAIN RATE

STRAIN

CALC

CHECK

APPRO

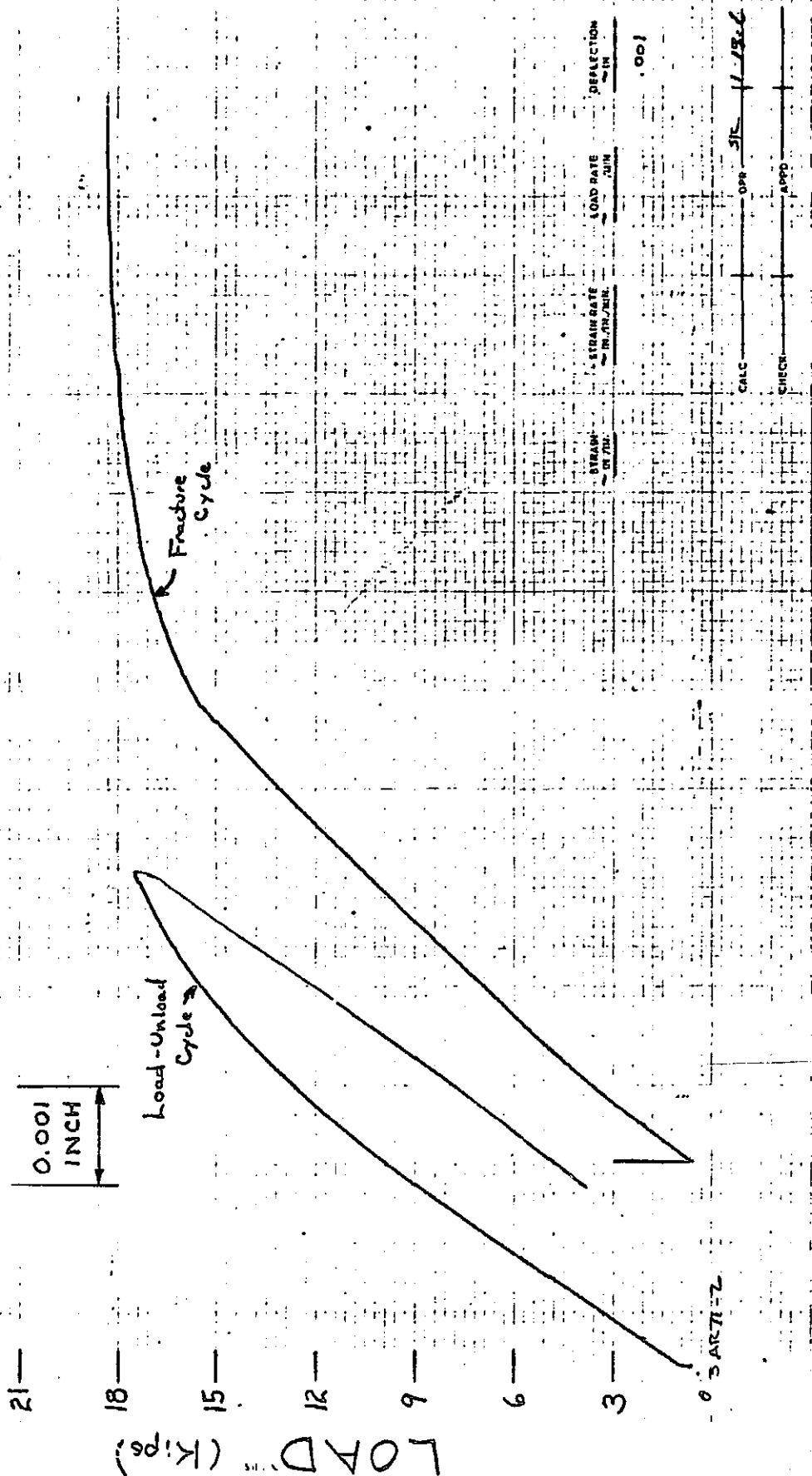
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ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3A871-2



115-002

BOEING

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115-002

OPR

CALC

CHECK

APPR

Page 01

BOEING

115-002

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115-002

OPR

CALC

CHECK

APPR

18—

16—

14—

12—

10—

8—

6—

4—

2—

Load (Kips)

Load - On load
Cycle

0.001
INCH

17,460

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR71-1

20—

16—

12—

8—

4—

LOAD (KIPS)

Load (Kips)

Fracture
Cycle

0.002
INCH

ULT 19,440

4AR-71-1

4AR-71-1

SECTION
10
001

13-6

18 — LU. 17,520

16 — Load-Unload Cycle →

14 —

12 — 0.001 INCH

Load (Kips)

10 —

8 —

6 —

4 —

2 —

0 4AR 71-2

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR71-2

20 —

16 —

12 —

8 —

4 —

LOAD LOSS

(Kips)

Load

Fracture Cycle

0.002 INCH

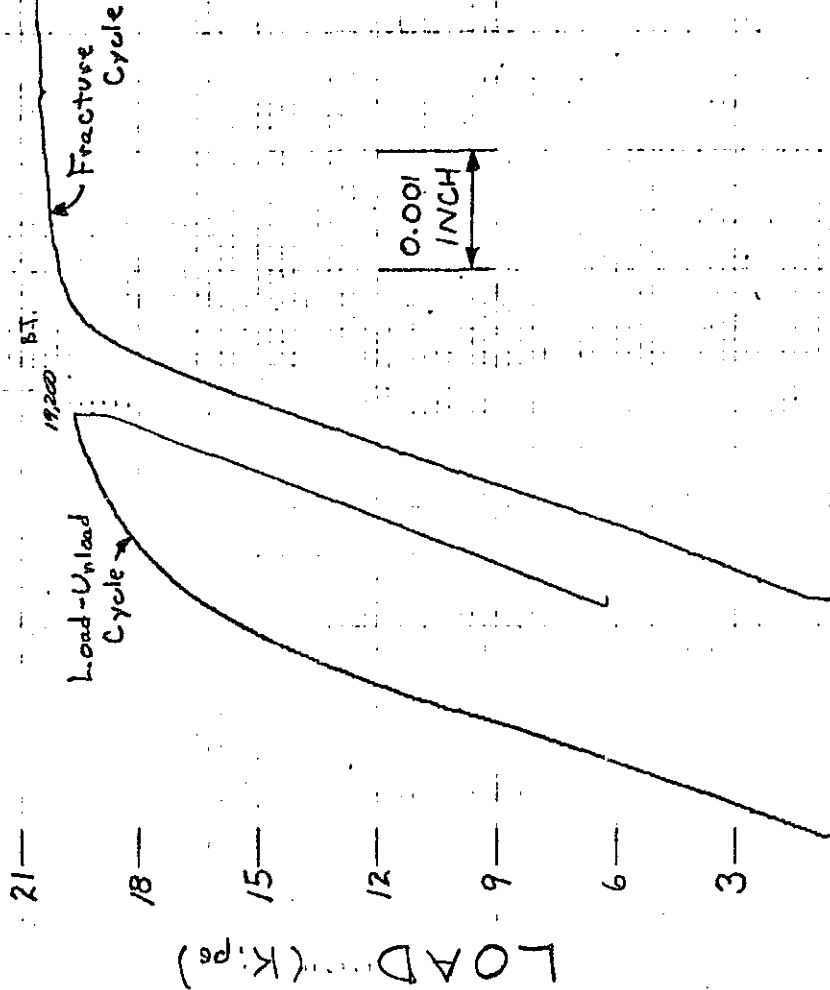
4AR 71-2

UL 17,300

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR73-1

UY 20,700



2AR73-1

STRAIN IN/IN
LOAD RATE LBS/IN
DEFLECTION IN/IN

CALC CHECK APPD

BOEING 100

310-001

1976 30 5 7/8

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR73-2

0.001
INCH

ULT 20,400

Fracture
Cycle

LU 15,750

Load-Unload
Cycle

1st Cycle
Cyclic Test

21—

18—

15—

12—

9—

6—

3—

2AR73-2

(Kips)

LOAD RATE
/MIN

STRAIN RATE
IN./IN.-MIN

STRAIN
IN./IN.

0.001

1-26-6

CALC

OPR

APPD

CHECK

COA

TPH

BOEING

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318-047

REVISION 25 - 8995

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR73-3

ULT. 20,200

21—

18—

15—

12—

9—

6—

3—

LOAD (Kips)

L.U 17,380

Load-Unload
Cycle

Fracture
Cycle

0.001
INCH

< .001% >

SK. 2-2-6

2AR73-3

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AK73-4

21—

18—

15—

12—

9—

6—

3—

LOAD (KIPS)

K

LOAD 18,820

Fracture Cycle

ULT 20,460

0.001 INCH

100% >

SC-2.22

2AK 73-4

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3A173-2

21—

18—

15—

12—

9—

6—

3—

0 3A173-2

LOAD (KIPS)

Load-Unload
Cycle

Fracture
Cycle

0.001
INCH

DEFLECTION
IN

LOAD RATE
LBS/IN

STRAIN RATE
IN./IN./MIN.

STRAIN
IN./IN.

.001

SK-11-19-6

OPR

CALC

APPRO

CHECK

BOEING

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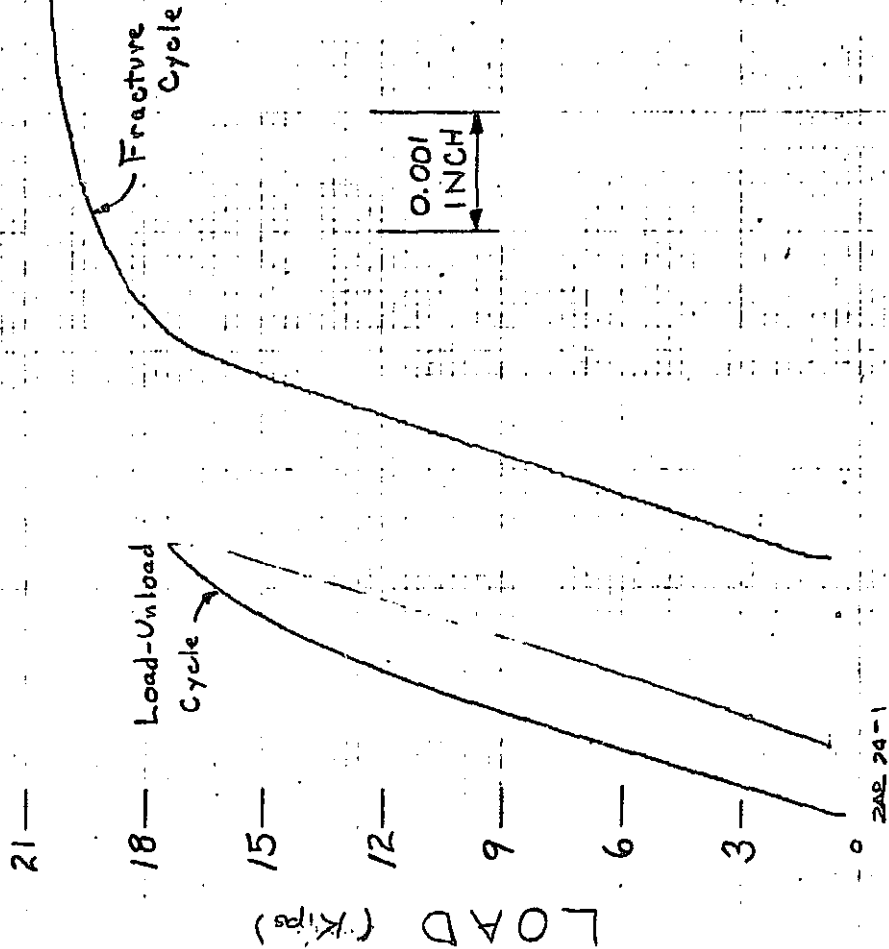
410-001

4-11-57, 0814 7001

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR74-1

ULT : 30,670



STRAIN IN / IN. STRAIN RATE IN / IN / MIN. LOAD RATE IN / MIN. DEFLECTION IN

.001

1.20-6

OPR

APPD

CHECK

CALC

73

2AR 74-1

BOEING

PR

PA

OF

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR74-2

027 29580

0.001
INCH

21—

18—

15—

12—

9—

6—

3—

0

LOAD (KIPS)

20 15580

Load-Unload
Cycle

Fracture
Cycle

2AR74-2

STRAIN RATE
IN./IN./MIN.
200

LOAD RATE
TON

DEFLECTION
IN

CALC ——— OPS — 38 — 120.6

CHECK ——— APPD ———

J19-047

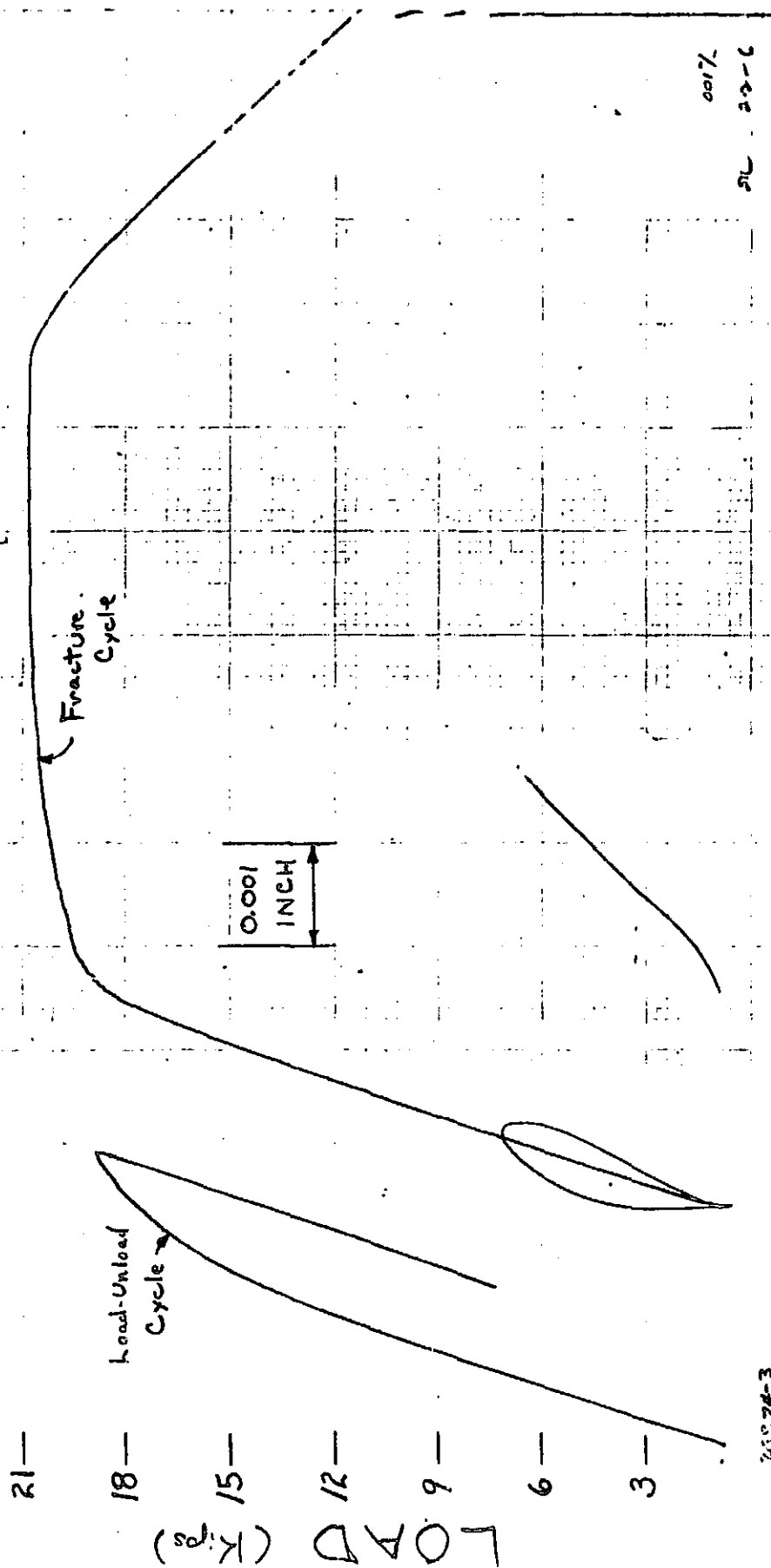
9-57 5-015 0480

BOEING TPR

PAGE 01

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR74-3



0017

22-6

2AR74-3

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR74-4

24—
21—
18—
15—
12—
9—
6—
3—

LOAD (Kips)

Fracture
Cycle

0.001
INCH

STRAIN RATE
IN/IN /MIN

LOAD RATE
KIPS

DEFLECTION
IN/IN

.001

2AR74-4

CALC

OPR

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2-8-6

CHECK

APPD

118-001

ENGINEERING

804

PAGE 07

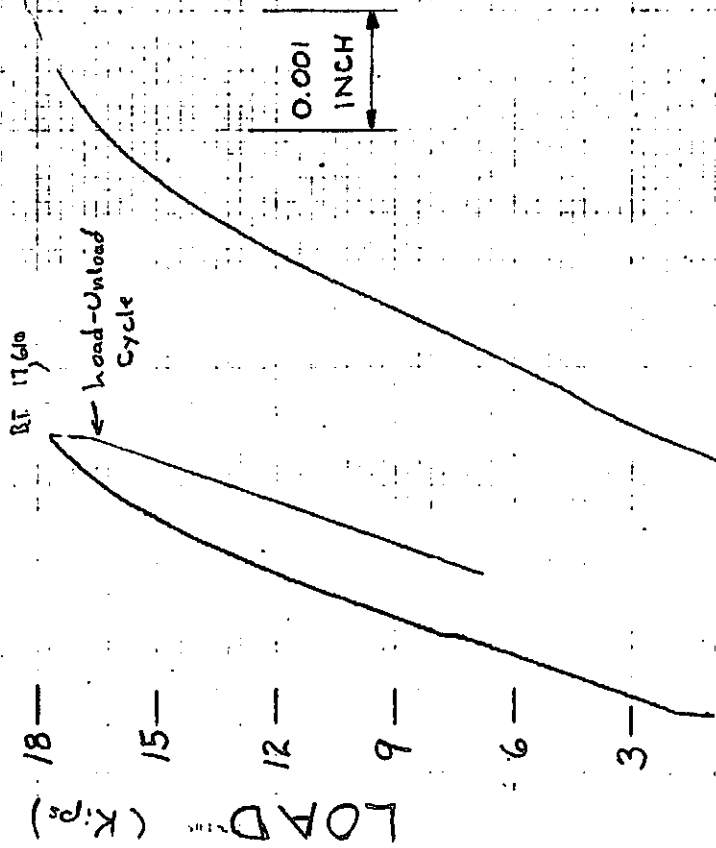
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ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3AR74-2

U47 19,450

21—



3AR74-2

LOAD RATE
IN/IN-MIN

STRAIN RATE
IN/IN-MIN

STRAIN
IN/IN

DEFLECTION
IN

001

CALC ———— OPR ———— R ———— 1-10-6
CHECK ———— APPD ————

18 —

16 —

14 —

12 —

10 —

8 —

6 —

4 —

2 —

4AR 74-1

L.U. 17,370 lbs.

Load-Unload Cycle

Load (Kips)

0.001 INCH

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR74-1

24

20

16

12

8

4

4AR 74-1

Load (Kips)

0.001 INCH

Failure Cycle

DEFLECTION

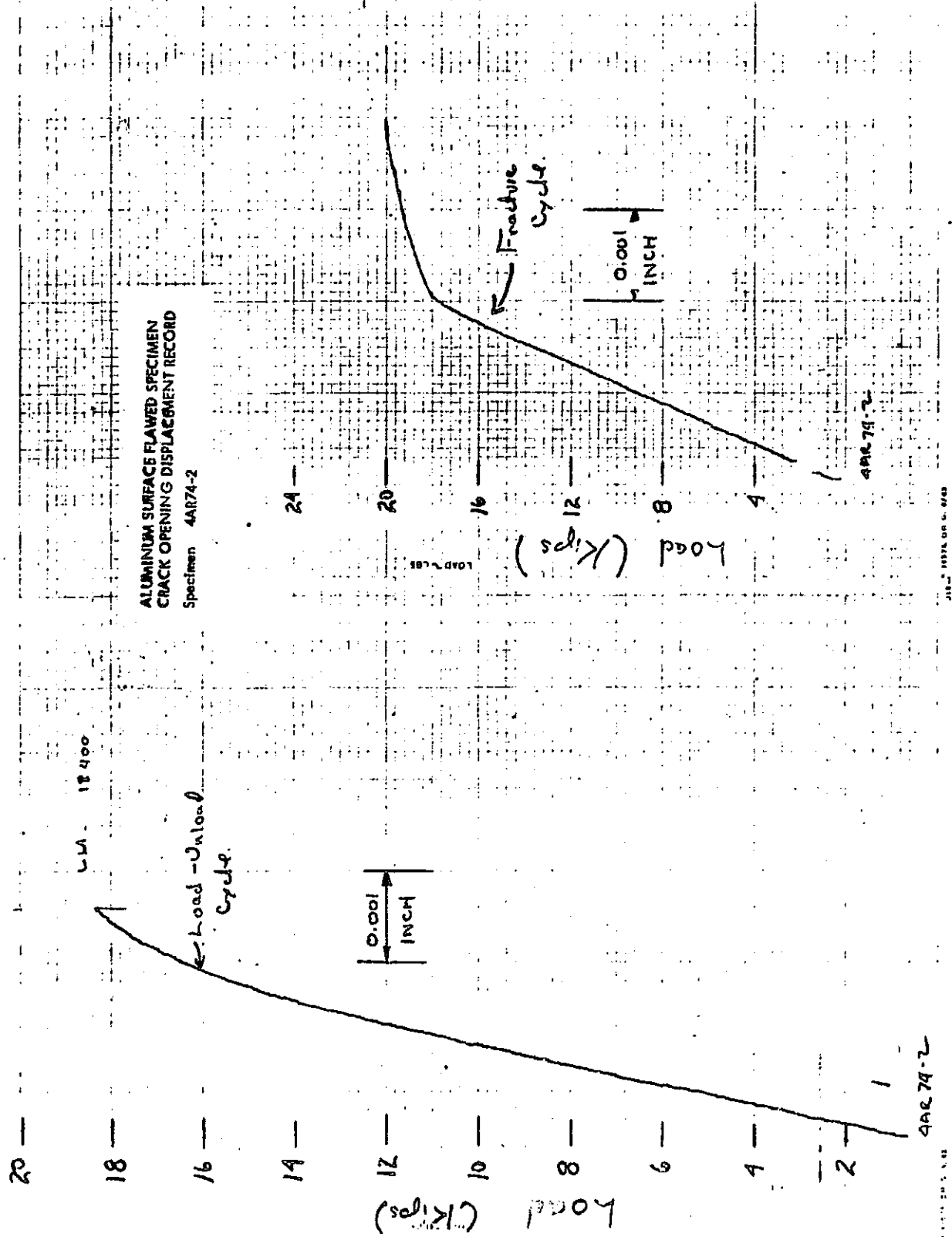
.001

0.001 INCH

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

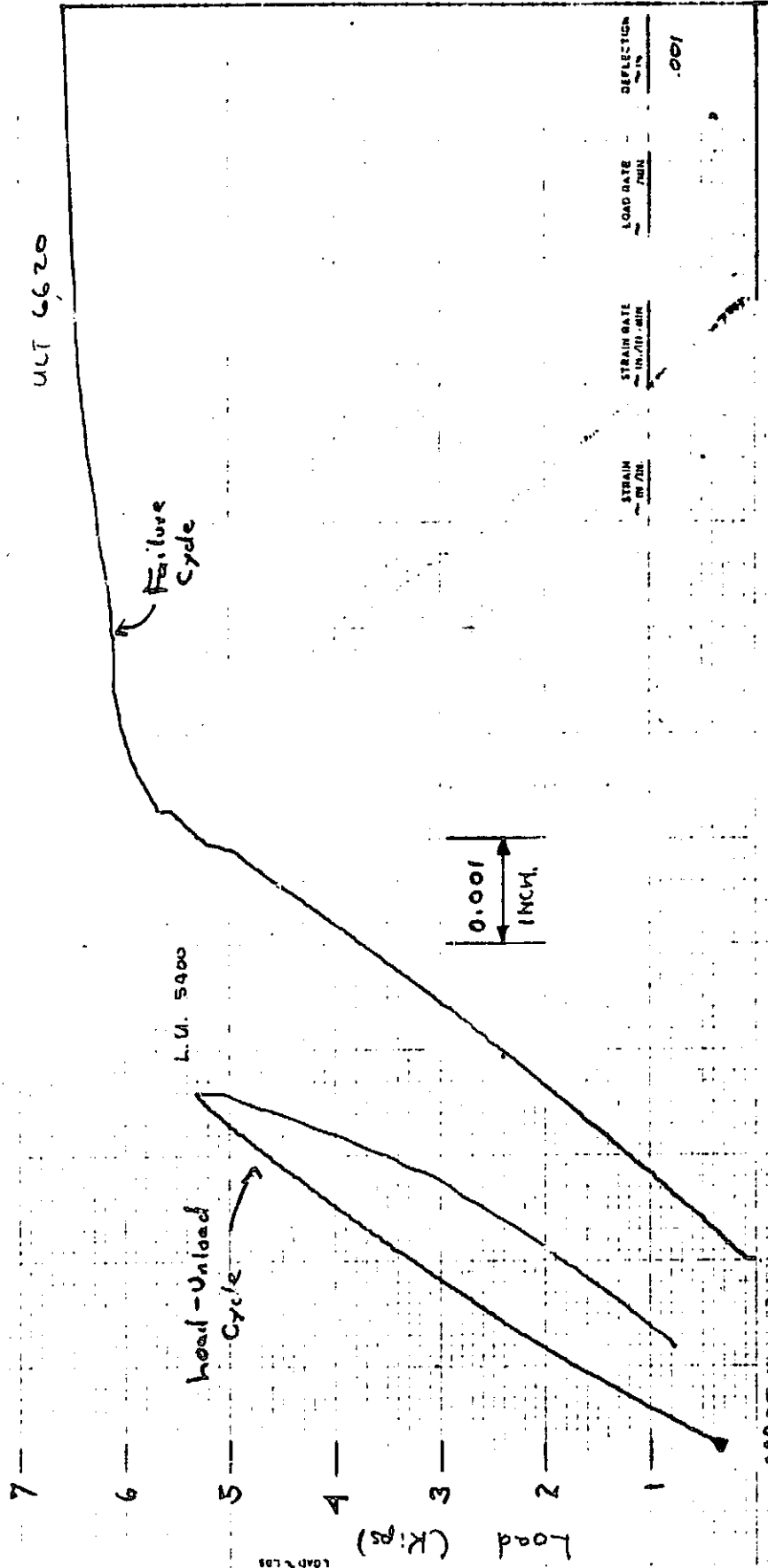
DISCREPANCY
MIN
-001

5-14-6



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2AR25-4



CALC. _____ JPR. 2K. 10-10-60

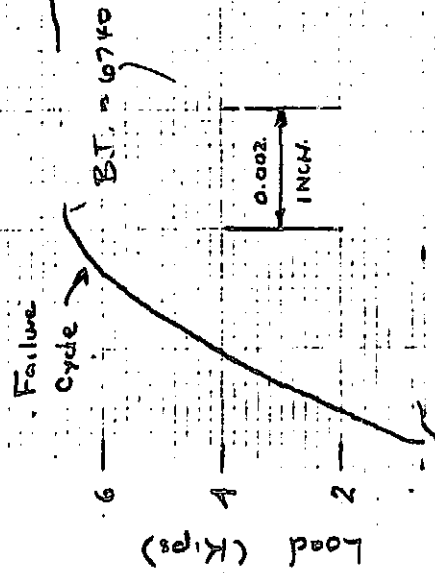
CHECK _____ APPD. _____

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ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR25-1

UL7 7020



3AR 25-1

STRAIN RATE
IN / IN.
STRAIN RATE
IN / IN.
LOAD RATE
IN / IN.
DEFLECTION
IN

CALC 5% 5/22-6

CHECK 5% 5/22-6

BOEING

418-043

418-043

7—

6—

5—

4—

3—

2—

1—

Load (Kips)

0.0004
INCH

Load-Unload
cycle

L.U. 5696

ALUMINUM SURFACE FLA-TED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR25-2

STRAIN RATE
IN/IN MIN
LOAD RATE
MIN
DISPLACEMENT
IN/IN

3AR25-2

CALC

008

516

16-3-6

CHECK

1995

GOENIS

TPR

16-3-6

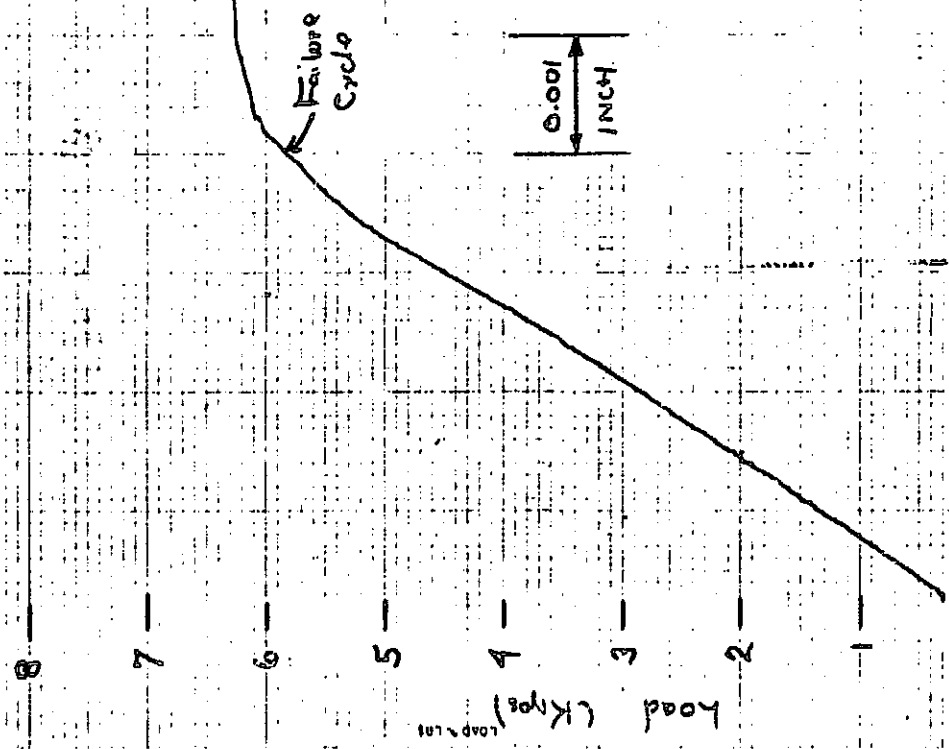
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ORIGINAL PAGE IS POOR.

UL7 6610 606

ALUMINUM SURFACE FLOWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR25-2



STRAIN RATE
IN./IN.
LOAD RATE
K/IN.
DISPLACEMENT
IN.

CALC. CHECK. OPER. APPROV.

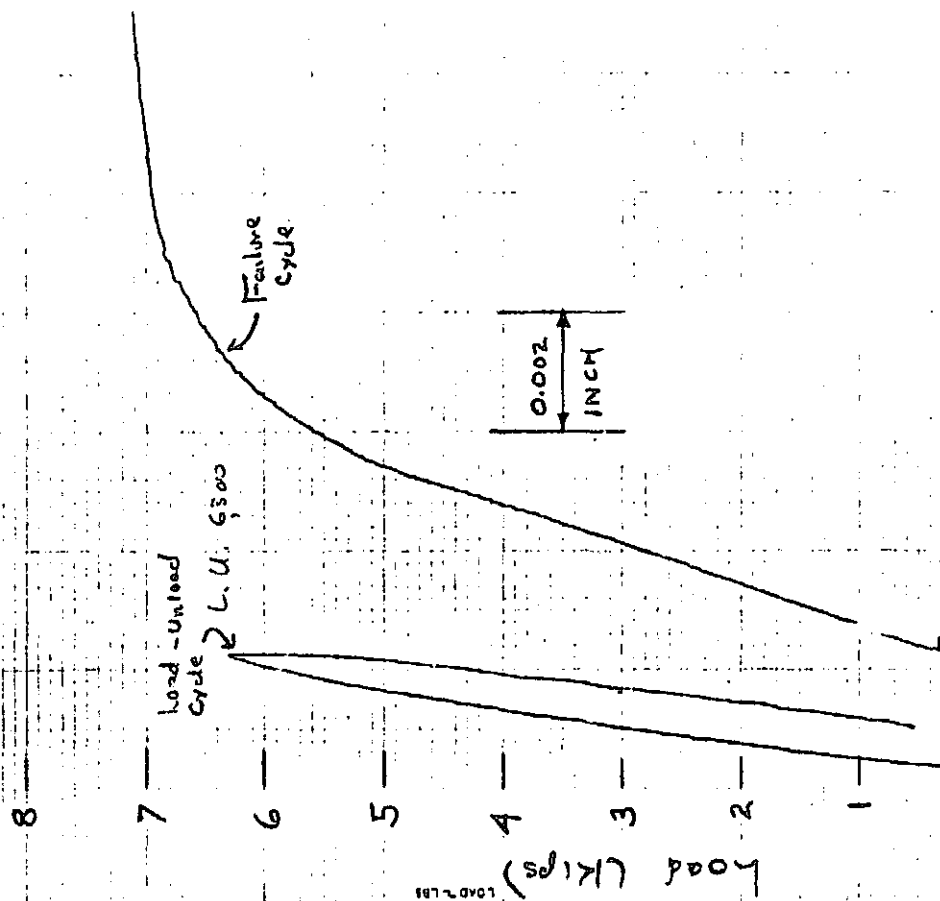
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J10-003

3 AR25-2

DLT 7190

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2AR21-3



2AR 21-3

STRAIN	STRAIN RATE	LOAD RATE	DISPLACEMENT
IN/IN	IN./IN. MIN	POUNDS	INCHES

CALC _____ 000 51 5-128

CHECK _____ 4800

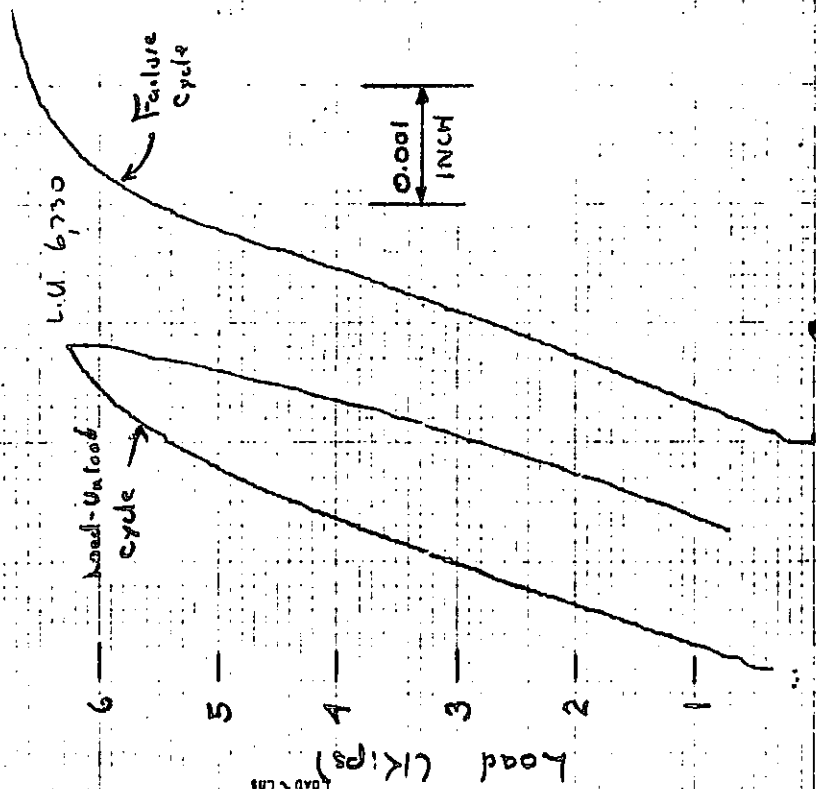
218-047

218-047

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ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2AR21-4

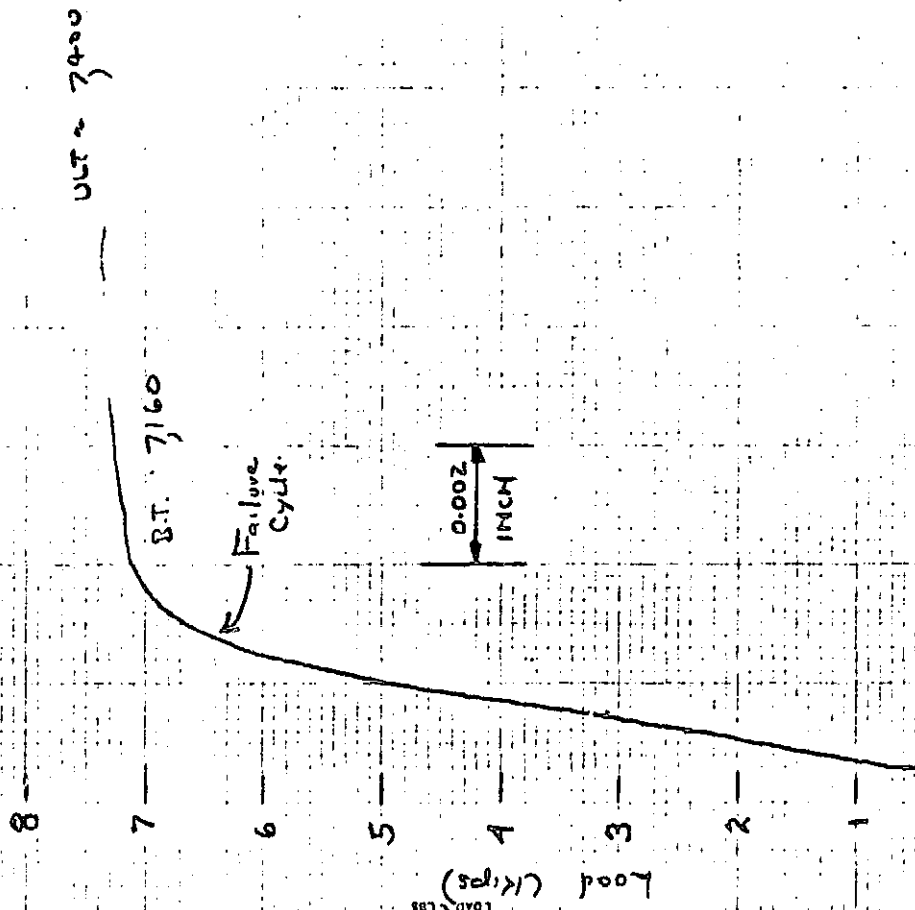


2AR21-4

STRAIN RATE $\sim 10^{-4}$ IN/IN MIN
LOAD RATE $\sim 10^{-4}$ IN/IN MIN
DEFLECTION $\sim 10^{-4}$ IN

CALC $\sim 10^{-4}$ IN/IN MIN
CHECK $\sim 10^{-4}$ IN/IN MIN

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR21-1



STRAIN RATE
IN./IN./MIN.

LOAD RATE
IN./MIN.

DEFLECTION
IN.

0.002

CALC

OPD

3-12-6

CHECK

APFD

BEING

TPR

ERA

PAGE

OF

JIS-037

WHITE OIL, 0/20

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

ULT. 7400

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2AR23-3

Failure
Cycle

Load: Unload L.L. 5480
Cycle

0.0005
INCH

Load (Kips)

2AR23-3

STRAIN RATE
INCH/IN MIN
LOAD RATE
LBS/IN MIN
DEFLECTION
INCH
5005

CALC
CHK
OPR
APP

DATE
PAGE

110-047

WHITE 3000 000

8

7

6

5

4

3

2

1

Load (Kilograms)

ULT 7300

Failure
Cycle0.001
INCH

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR23-2

LOAD RATE
IN/IN MIN
0.001

STRAIN RATE
IN/IN MIN
0.001

STRAIN
IN/IN
0.001

CALC _____ DISPLACEMENT _____ SK 0.25

CHECK _____ DISPLACEMENT _____

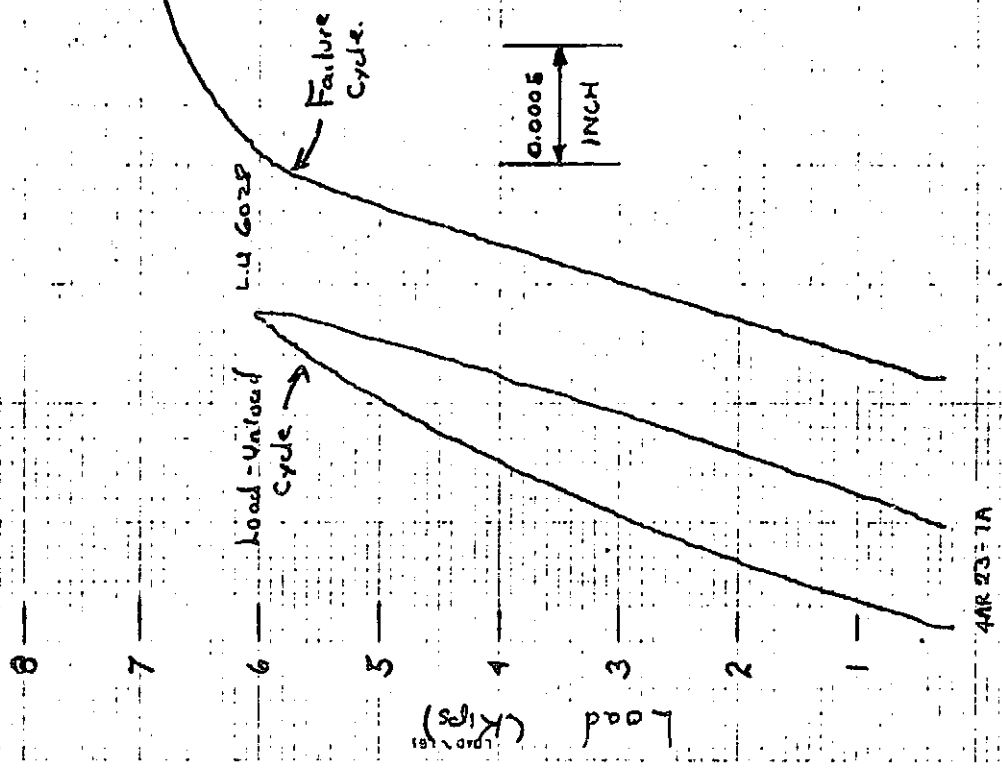
JIS-001

FORM 100
PAGE 10

3AR23-2

U.S. 7520

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR23-1A



STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN	IN/IN	IN/IN
			.0005

CALC _____ DATE 2-13-6

CRACK _____ APPD _____

TESTING TYPE _____

115-007

89

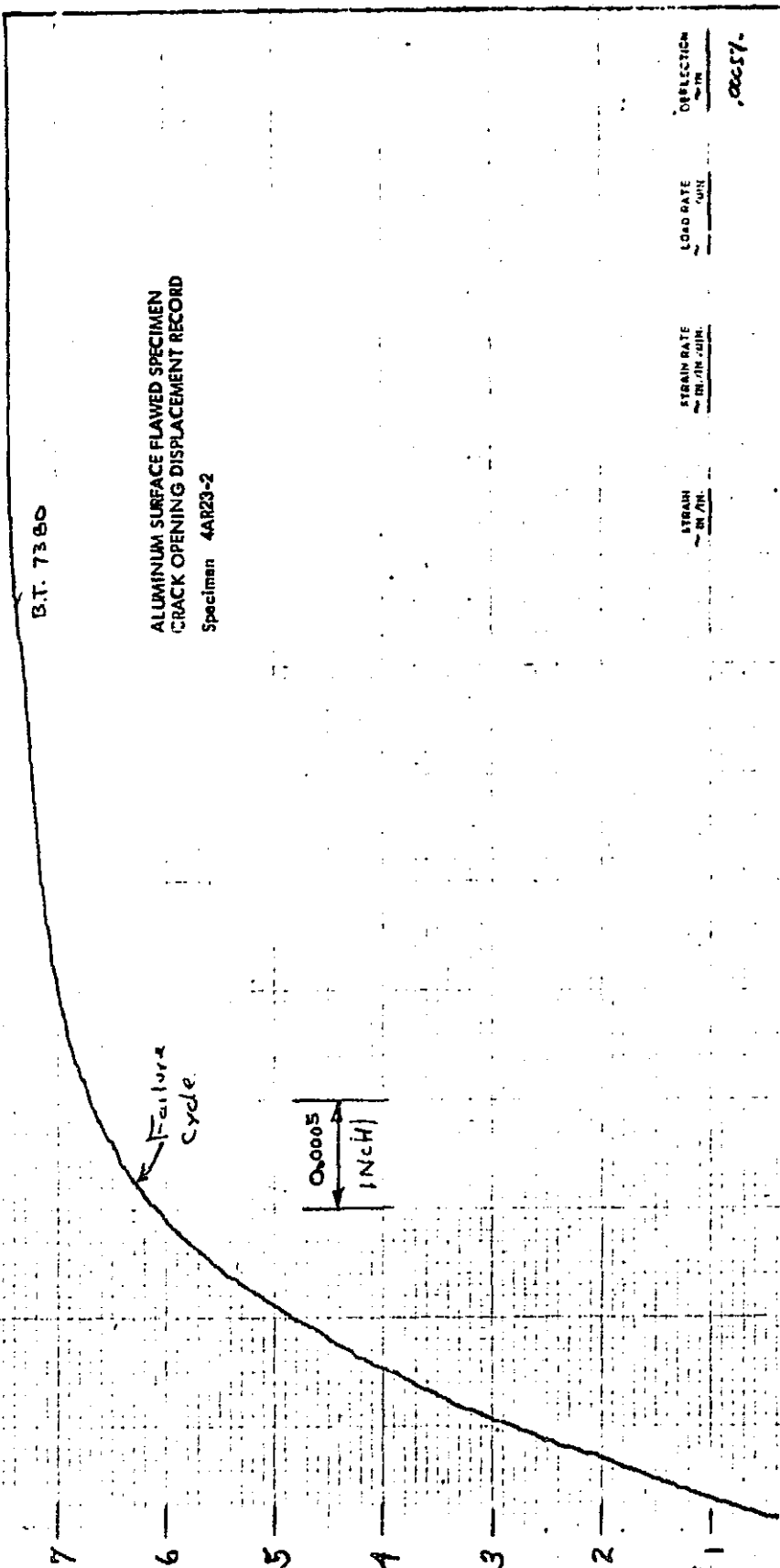
ULT 7420

B.T. 7380

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR23-2

8
7
6
5
4
3
2
1

(Kips)
Load



STRAIN IN/IN.	STRAIN RATE IN/IN MIN.	LOAD RATE KIP/MIN.	DISPLACEMENT IN.
			0.0051

CALC	CFR	7-12-76
CHECK	APD	

BUREAU OF
ROADS
PAGE 61

318-007

DATE ON S. 4/42

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AH11-1

0.002
INCH

Fracture Cycle

Load-Unload
Cycle

Cyclic Test

300 = STOPPED, NO BREAKTHRU

SPECIMEN 2AH11-1
CYCLE TO BREAKTHRU AT 927F
AREA = 1.4170 IN²
TULAHIP 1-21-76

CRACK DEPTH 0.002 IN/IN

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AH11-2

0.002
INCH

80

70

LOAD (KIPS)

60

50

40

30

20

Cycle Test

1 5 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 BREAKTHRU AT 310 CYCLES

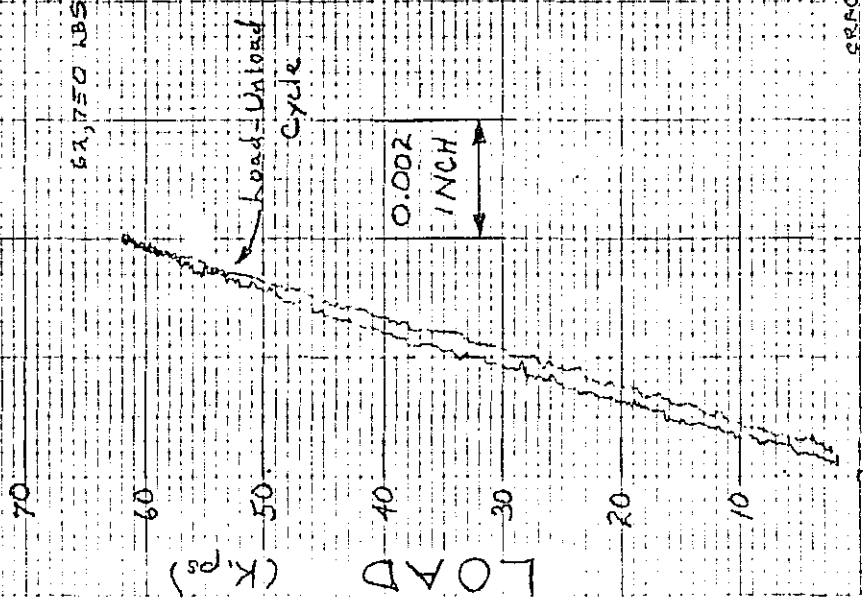
SPECIMEN 2AH11-2
CYCLE TO BREAKTHRU AT - 423 °F
AREA = 1.3982 IN²
TULALIP 1-22-76

CRACK DEFL. V. LOAD IN/IN

ALUMINUM SURFACE FLAWED SPECIMEN CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AH11-3

62,750 LBS



SPECIMEN 2AH11-3
LOAD/UNLOAD AT -423°F
AREA = 1260 IN²
TULAMP 1-23-76

CRACK DEFLECTION IN/IN

C-2

2-7-76

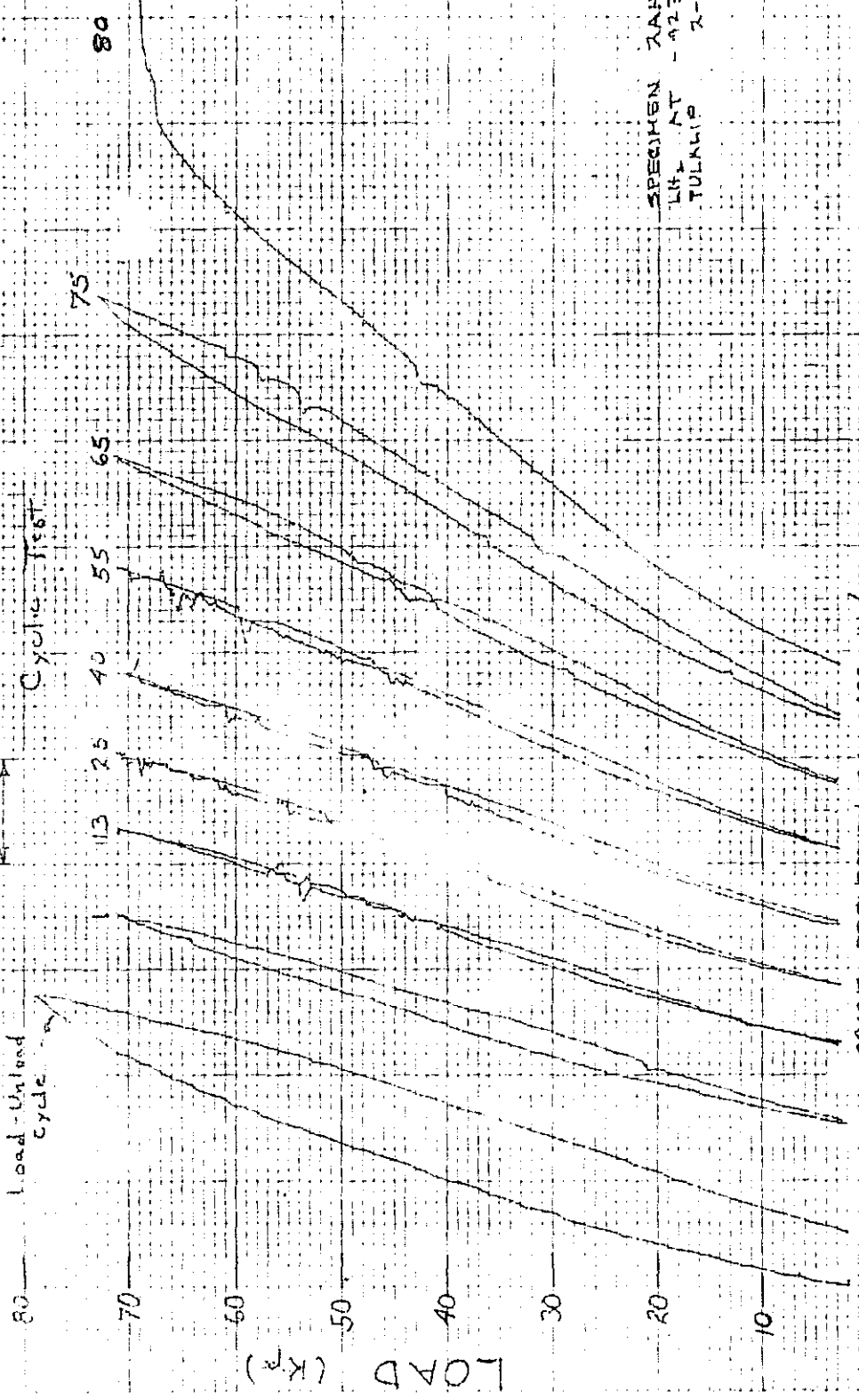
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AH11-4

0.002
INCH

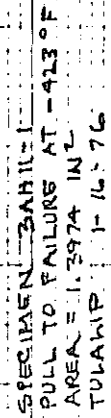
Load-Unload
cycle

Cyclic Test



SPECIMEN 2AH11-4
LH AT -923°F
TULALIP 2-7-76

Specimen - 3AH11-1



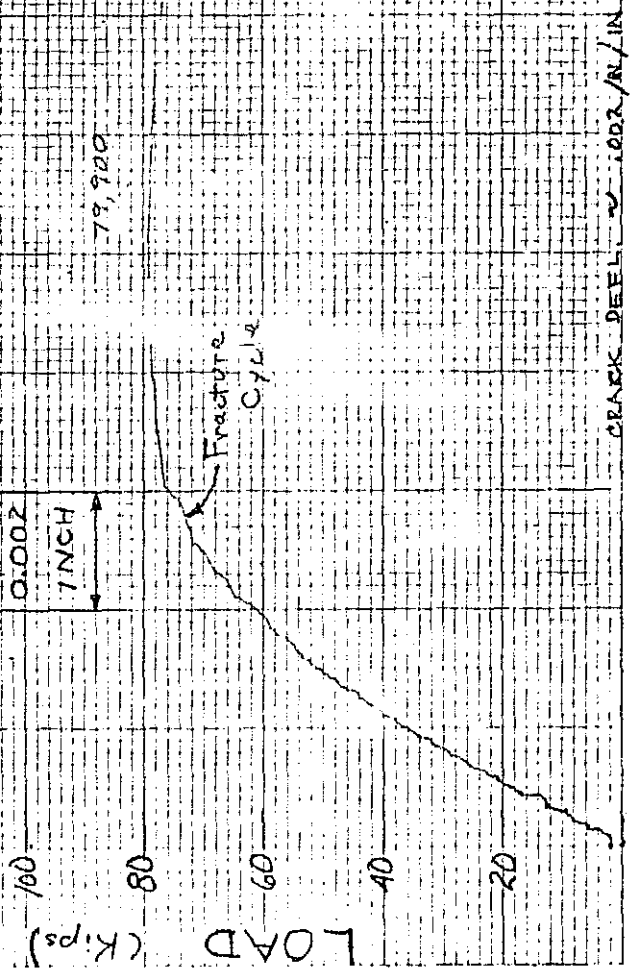
CRACK DEFLECTION 2.002 IN/IN

3AH11-2
-19-76

47 0703

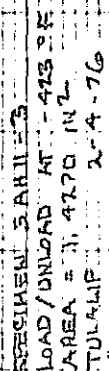
96

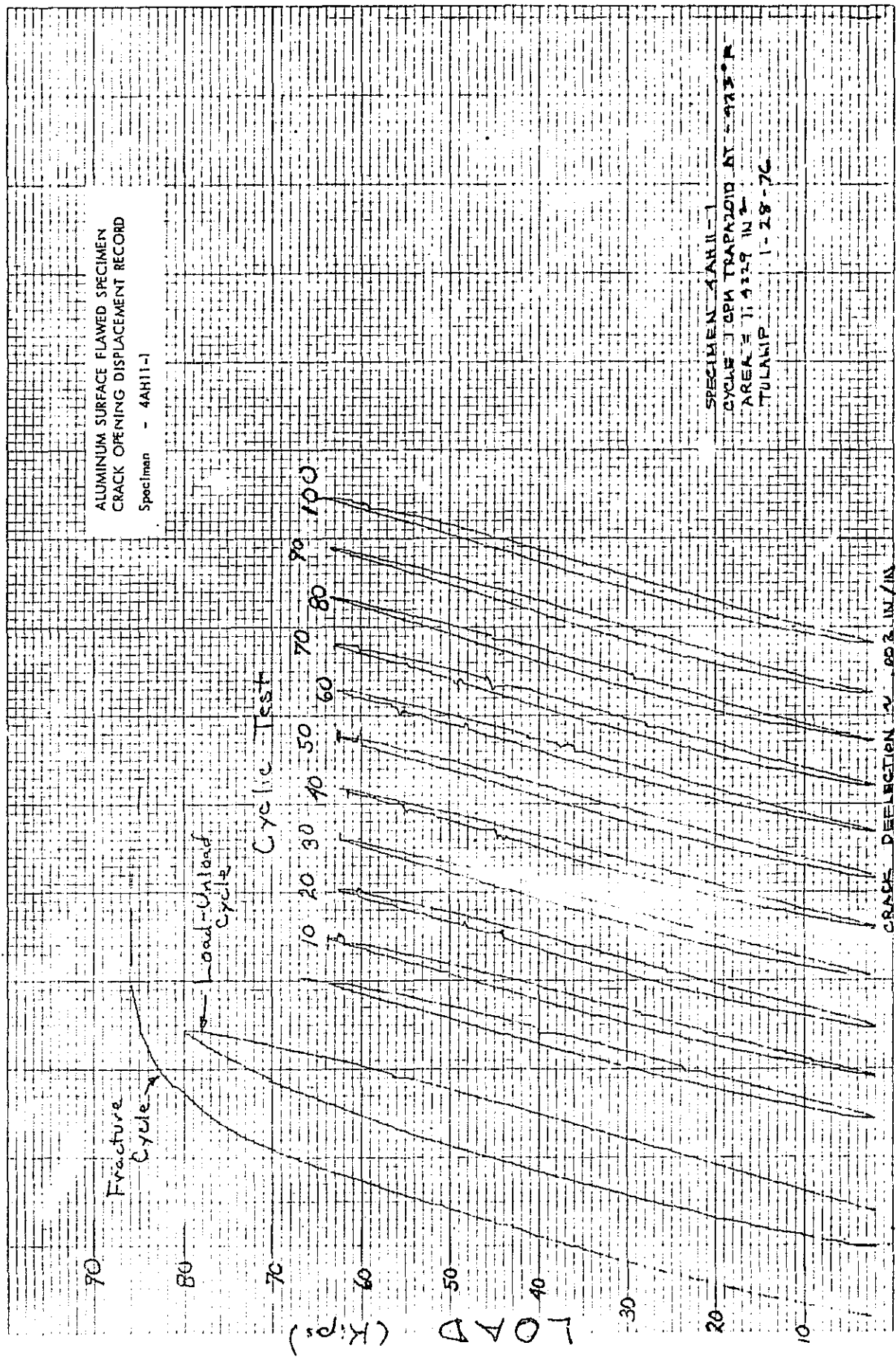
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH11-2



SPECIMEN 3AH11-2
PULL TO FAILURE AT -923 °F
AREA = 1.2107 IN²
TULAMP 1-19-76

Specimen - 3AH11-3



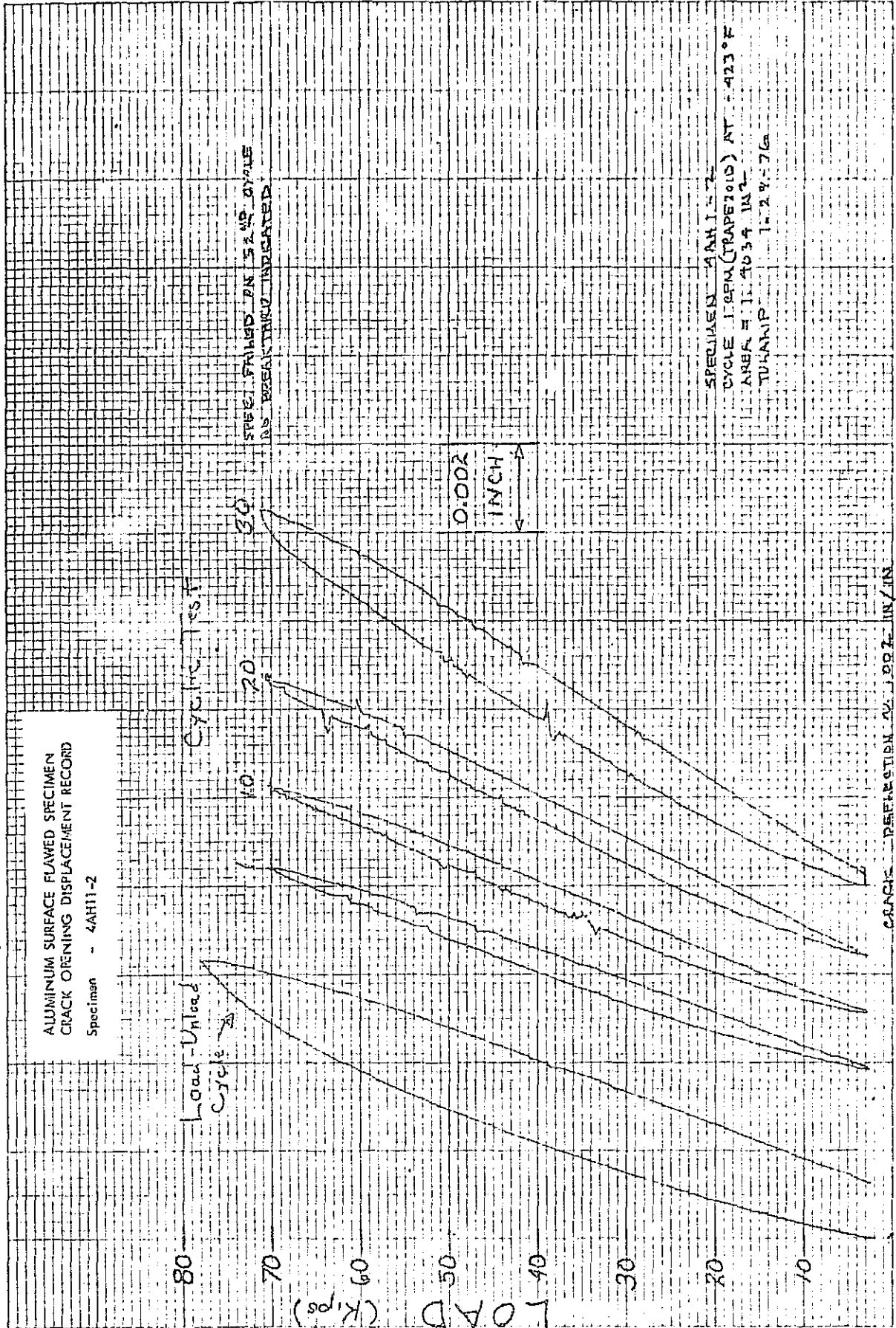


4AH1-2
1-24-76

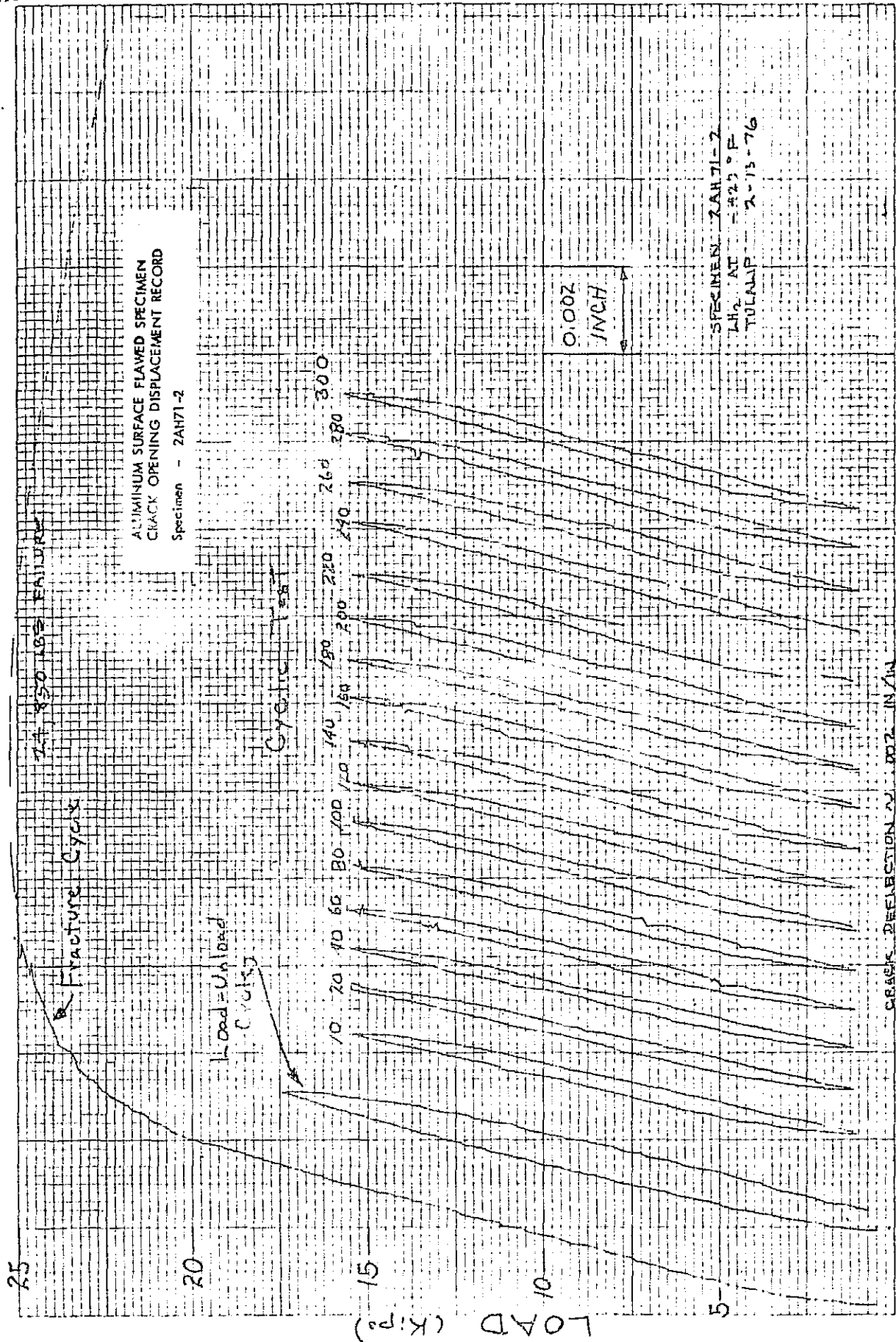
47 0703

85

K-2 ALUMINUM TO THE RIGHT SIDE

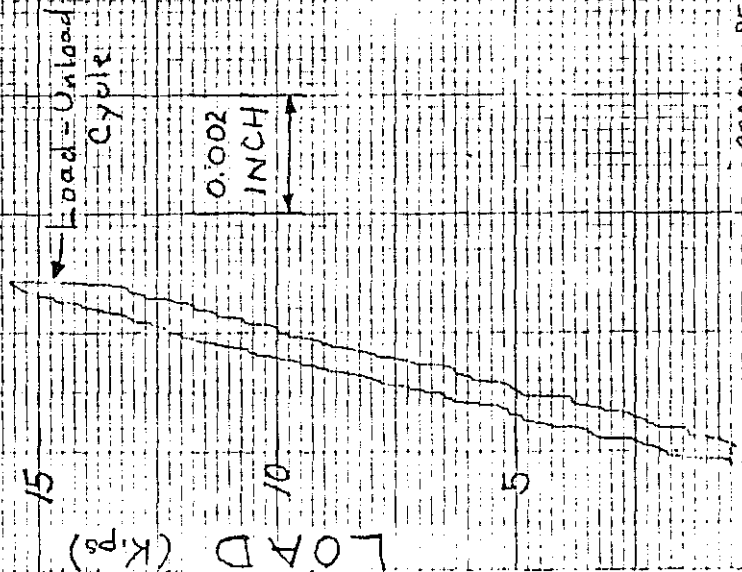






ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AH71-3

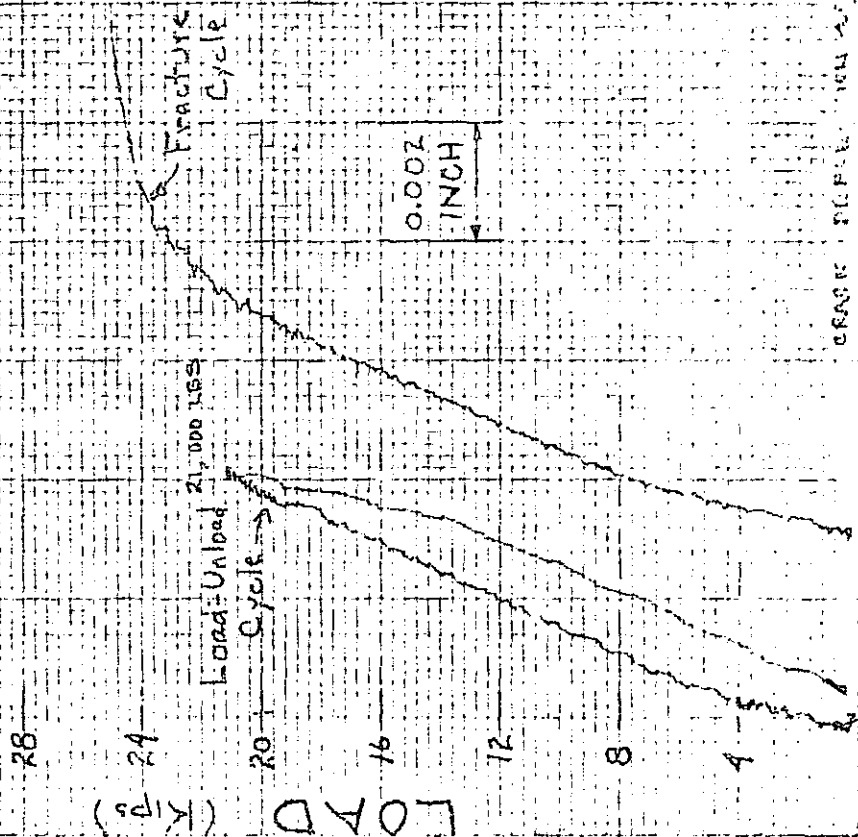


SPECIMEN 2AH71-3
JH2 AT - 423°F
TULAH, MS 2-11-76

CRACK OPENING DISPLACEMENT (INCH)

Specimen - 2AH71-4

SPECIMEN 2A471-A
LH2 AT - 92E OF
TULAWIP 2-23-76

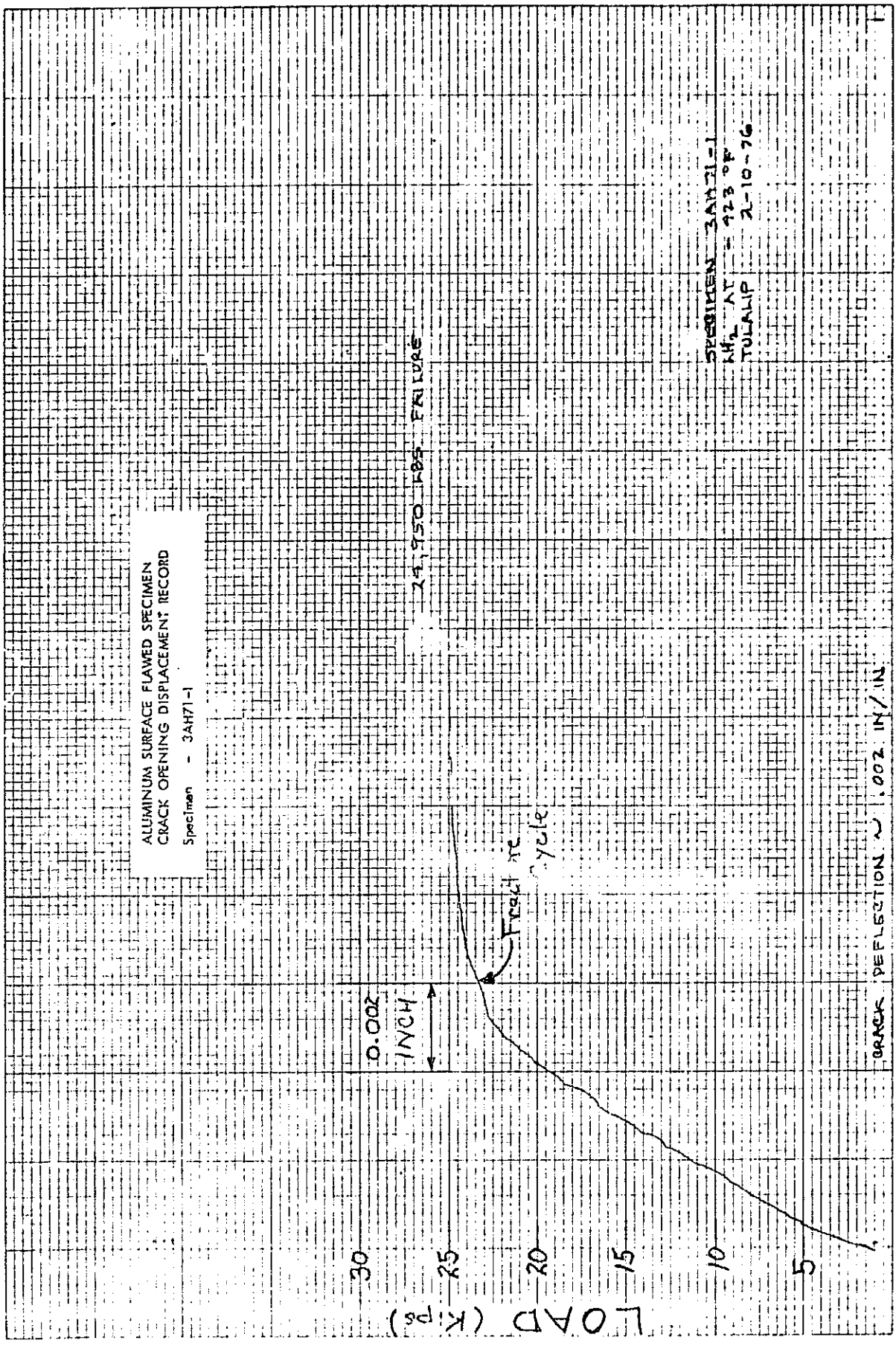


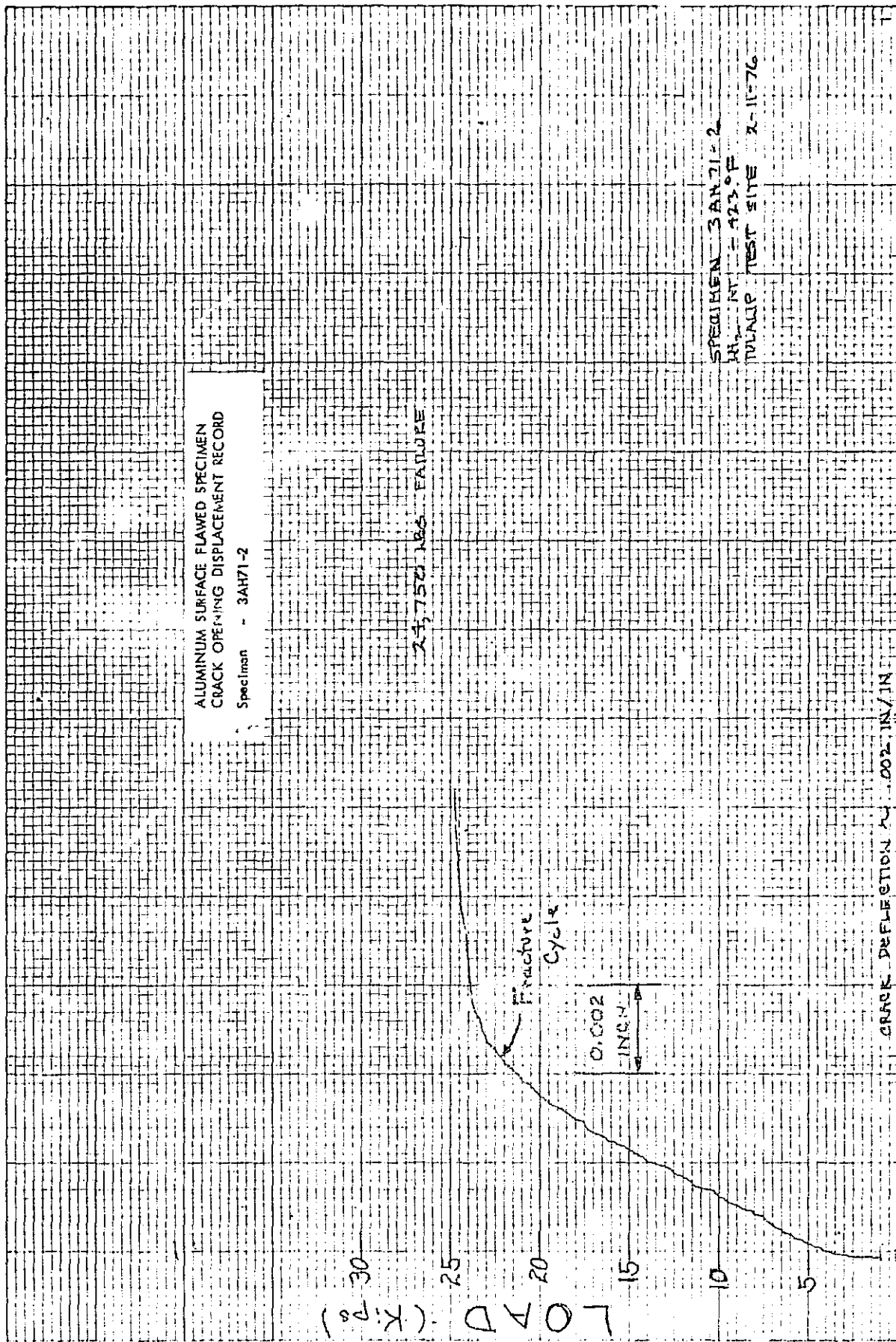
3AH71-1

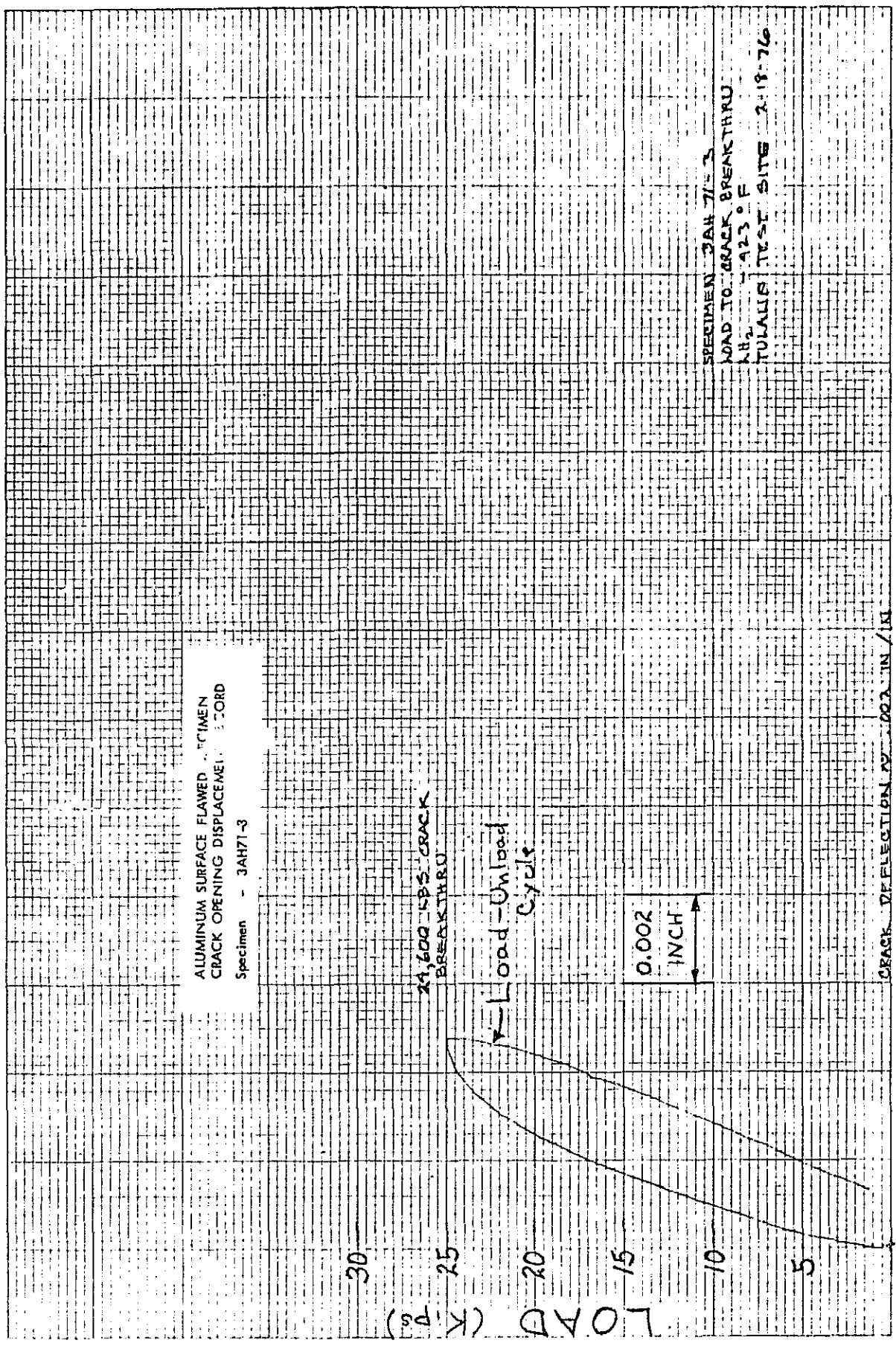
47 0/03

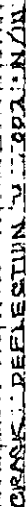
104

15:12 IN 3 TO 10 SEC. SCALE 2 IN/IN

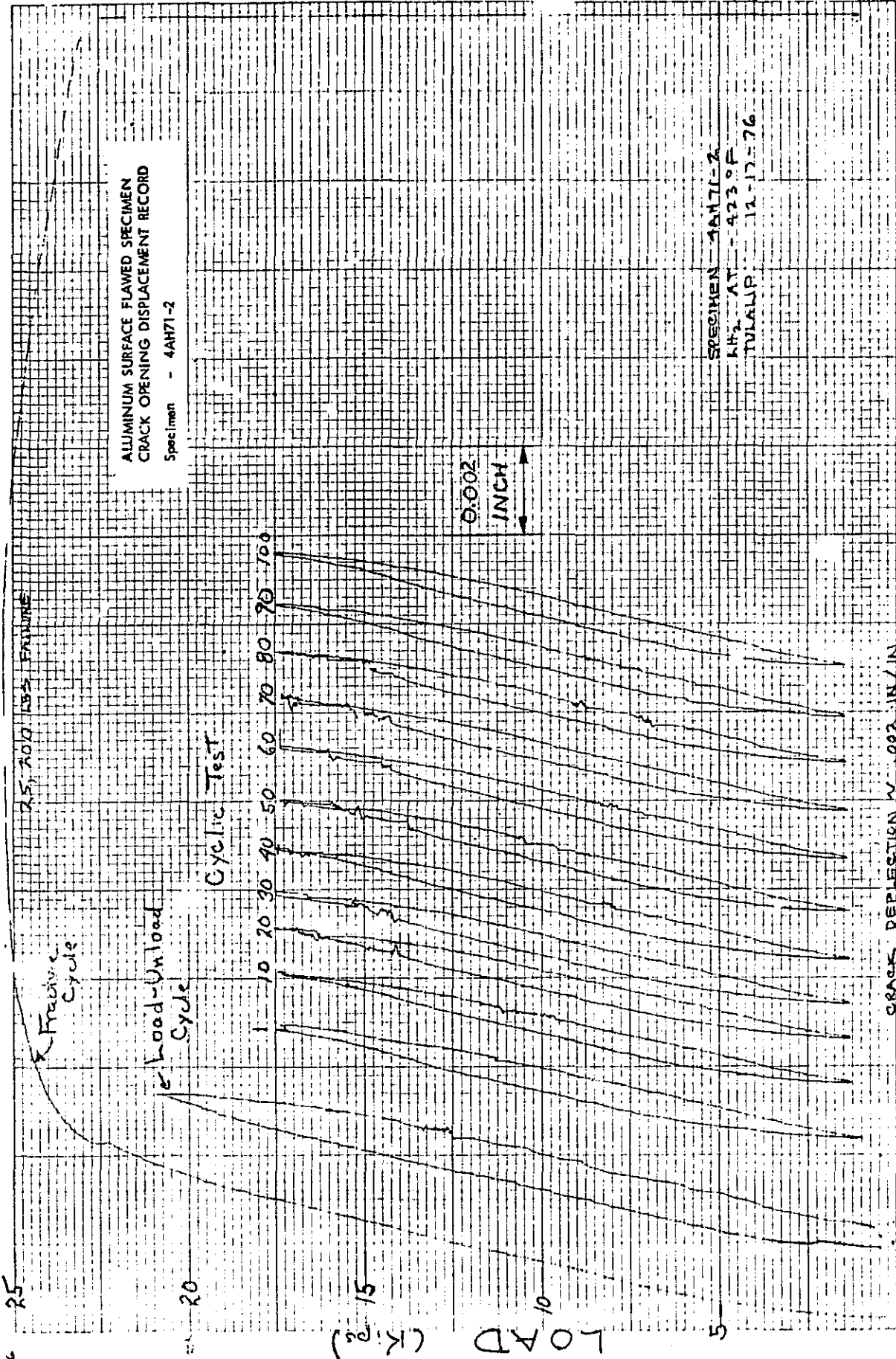






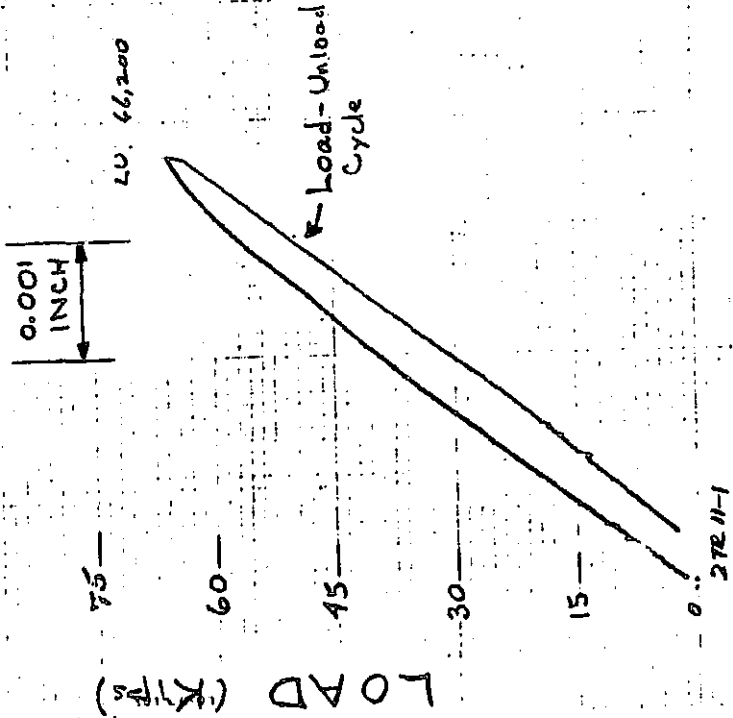


4AH71-2
2-17-76



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - ZTR11-1



STRAIN RATE
IN./IN./MIN.
LOAD RATE
LBS./MIN.
STRESS RATE
KSI./MIN.

CALC. OPER. DATE 26-12-66

CHECKED BY

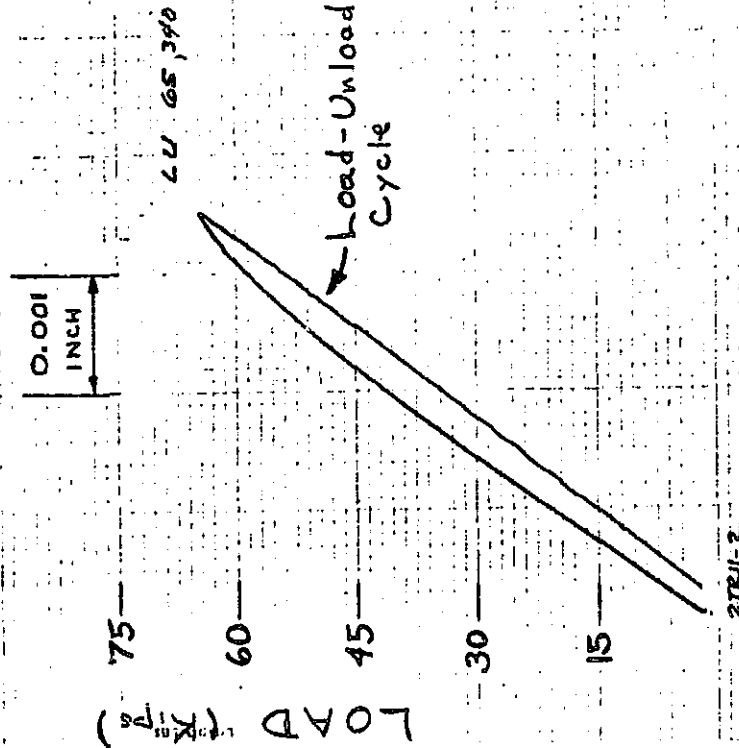
ENGINEER

PAGE 07

109-007

REPRODUCIBILITY OF THE ORIGINAL PAGE

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2TR11-2



STRAIN RATE
IN/IN/IN

STRAIN
IN/IN

LOAD RATE
LBS/IN

DEFLECTION
IN

CALC _____

CHECK _____

BOEING

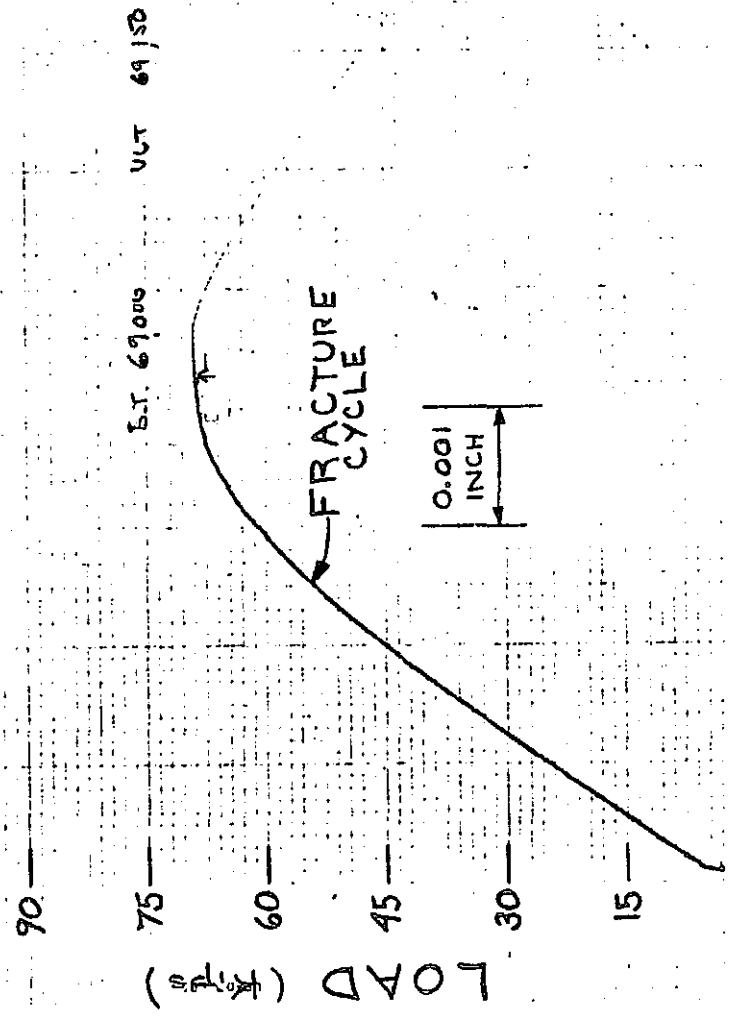
218-001

4 SURVE ORIG. W-6

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

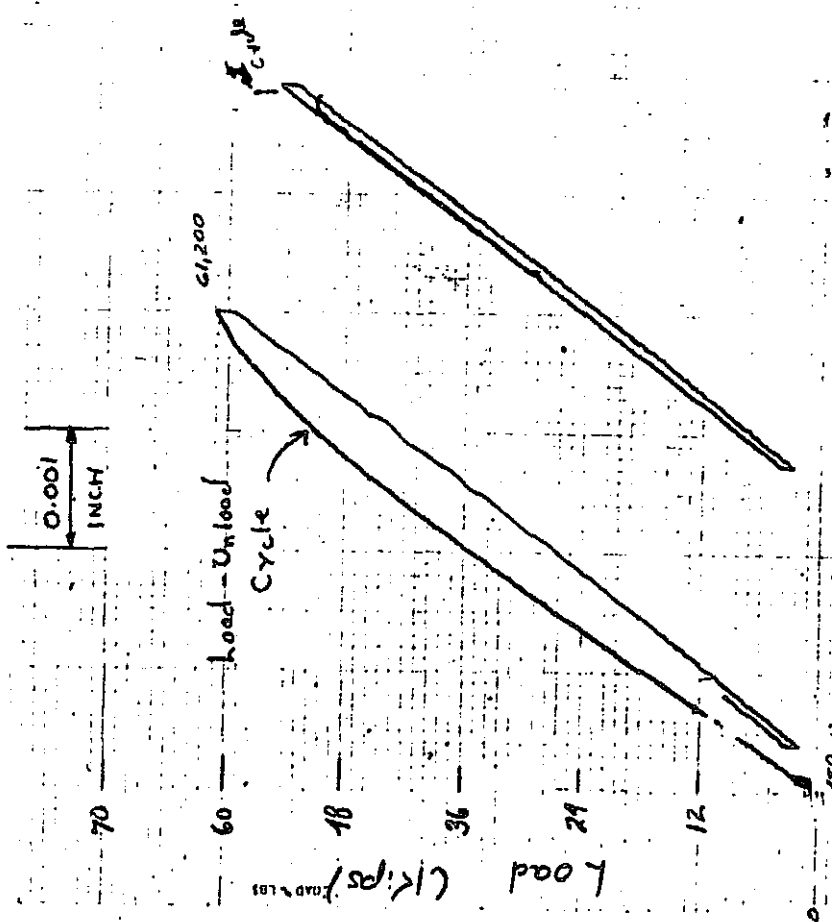
Specimen - 3TR11-1



STRAIN - 0.001
STRAIN RATE - 10%/MIN.
LOAD RATE - 7000
DEFLECTION - 0.001

Calc - OPR - 1-20-6
CHECK - 1-20-6
BOEING
PAGE 08

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4TR11-1



STRAIN RATE
IN./IN./MIN.
LOAD RATE
%
DEFLECTION
%
0.001

CALC 0-0 52 16-32-6

CHECK APPD

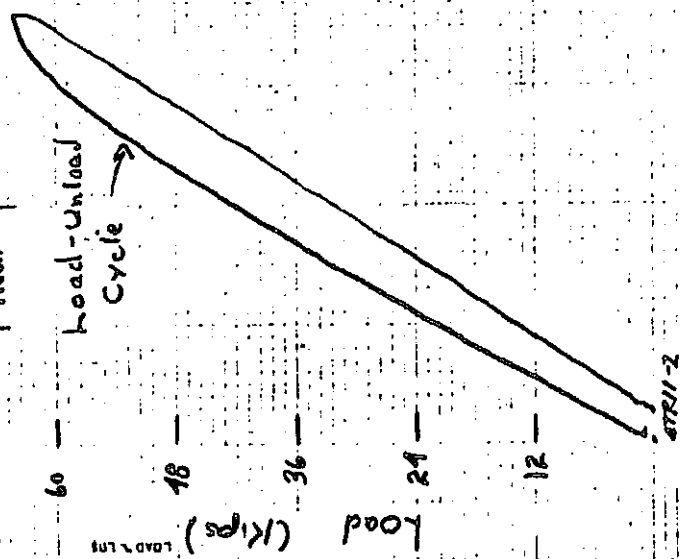
BUZING 11-2 FVA PAGE 01

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 47811-2

4.4 CF, 700

0.001
INCH



STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN	IN/IN	IN/IN

.001

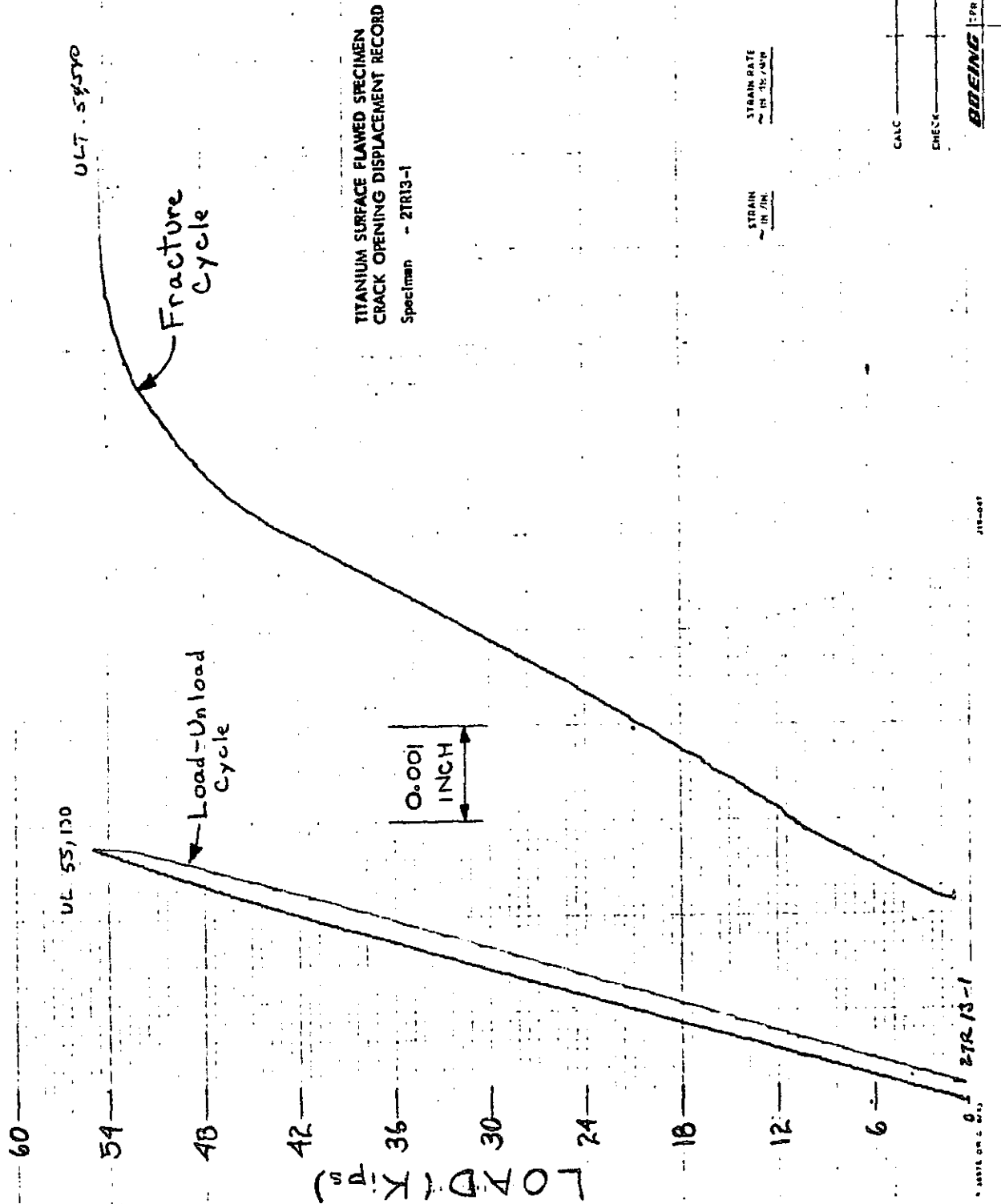
CALC. ———— OPR. ———— 5.2.6

CHECK ———— APP. ————

BEING IPR 1800 1800 1800

113-007

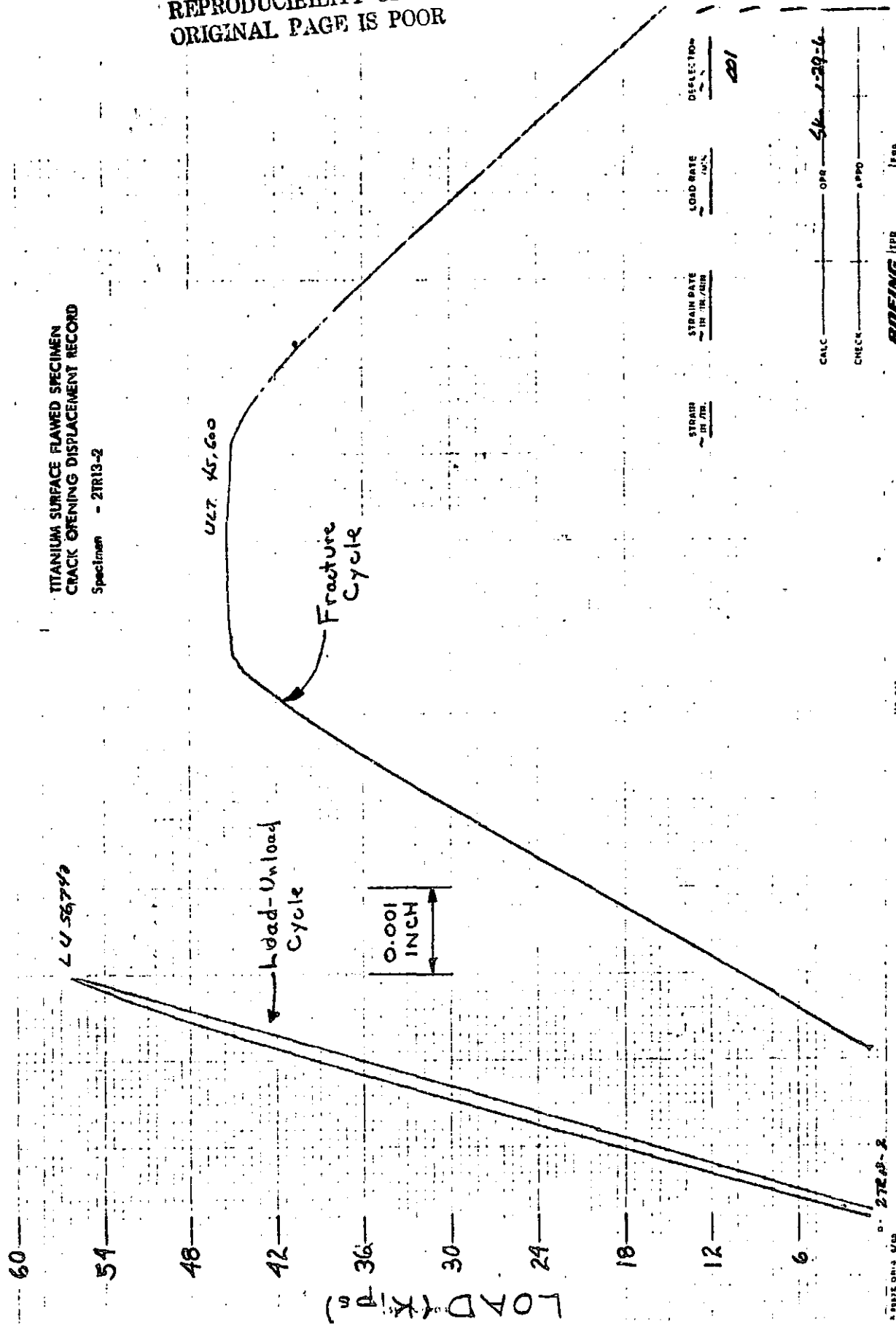
113-007



REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR13-2



STRAIN RATE
IN/IN/IN

LOAD RATE
IN/IN/IN

DEFLECTION
IN

CALC - 0.001 - 0.001 - 0.001 - 0.001

CHECK - 0.001 - 0.001 - 0.001 - 0.001

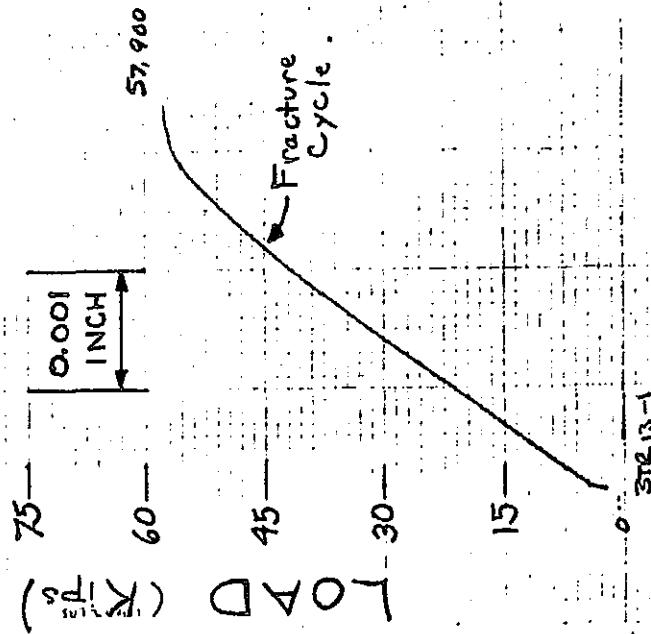
DATE - 1-29-66

BY - BDEING

2TR13-2

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3TR13-1



STRAIN $\frac{IN}{IN}$ _____
STRAIN RATE $\frac{IN}{IN \cdot MIN}$ _____
LOAD RATE $\frac{KIP}{MIN}$ _____
SELECTION $\frac{IN}{IN}$.001

CALC _____ OPB 26 1-20-6

CHECK _____ APPC _____

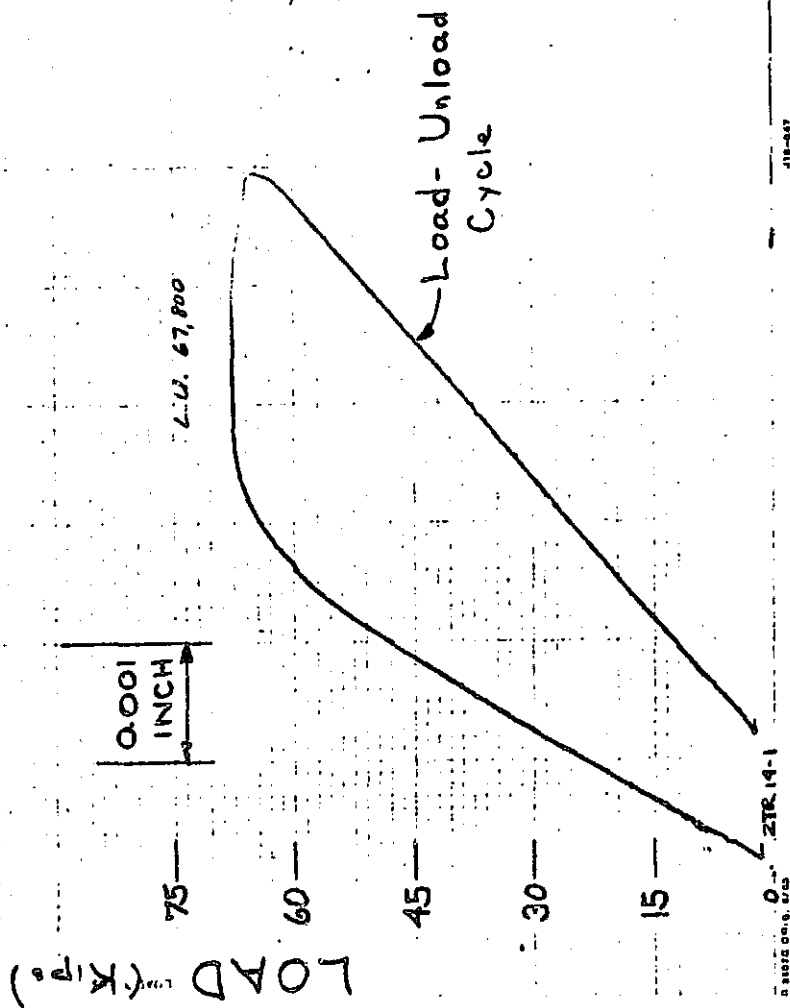
BDEING 10R 26 PAGE 01

J18-007

1 INCH OR 1/2 INCH

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen -2TR14-1



STRAIN RATE
IN/IN-MIN

LOAD RATE
K/IN-MIN

DEFLECTION
IN

CALC

CHECK

APPRO

DATE

1-22-66

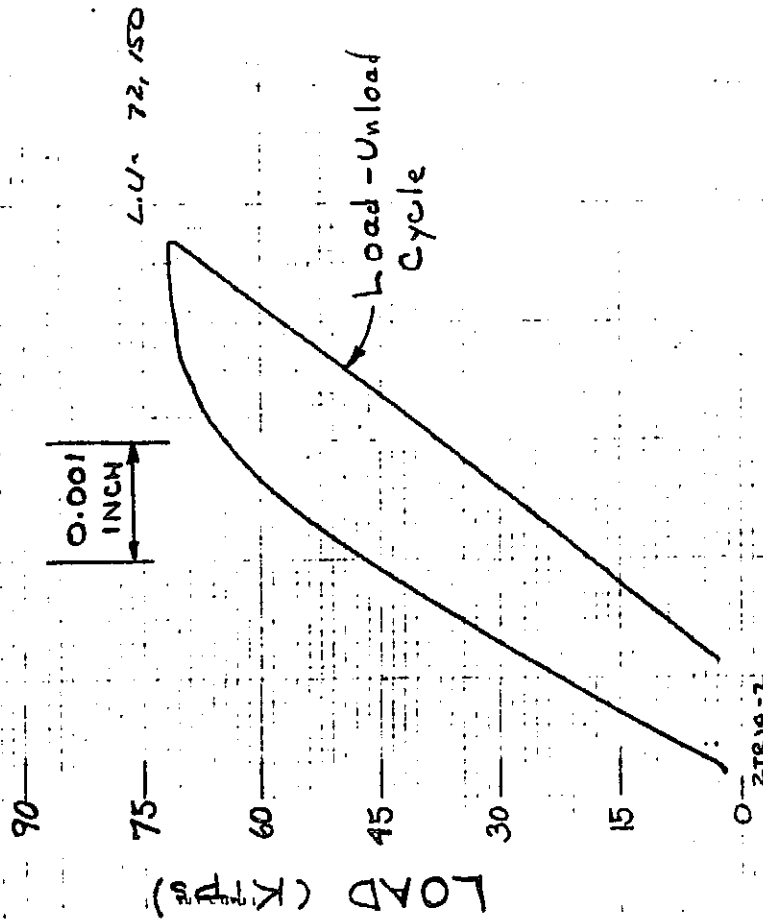
BENDING

PAGE

OF

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR14-2



STRAIN RATE
IN/IN MIN

LOAD RATE
LBS/IN MIN

DEFLECTION
IN/IN

CALC

CHECK

DATE

TIME

BOEING

TPD

DP

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3TR14-1

105—

90—

LOAD (KIPS)

75—

60—

45—

30—

15—

0

0.001
INCH

Fracture
Cycle

85,400

372.14

STRAIN RATE
IN/IN MIN
LOAD RATE
LBS/IN MIN
DEFLECTION
IN

.001

CALC

CHECK

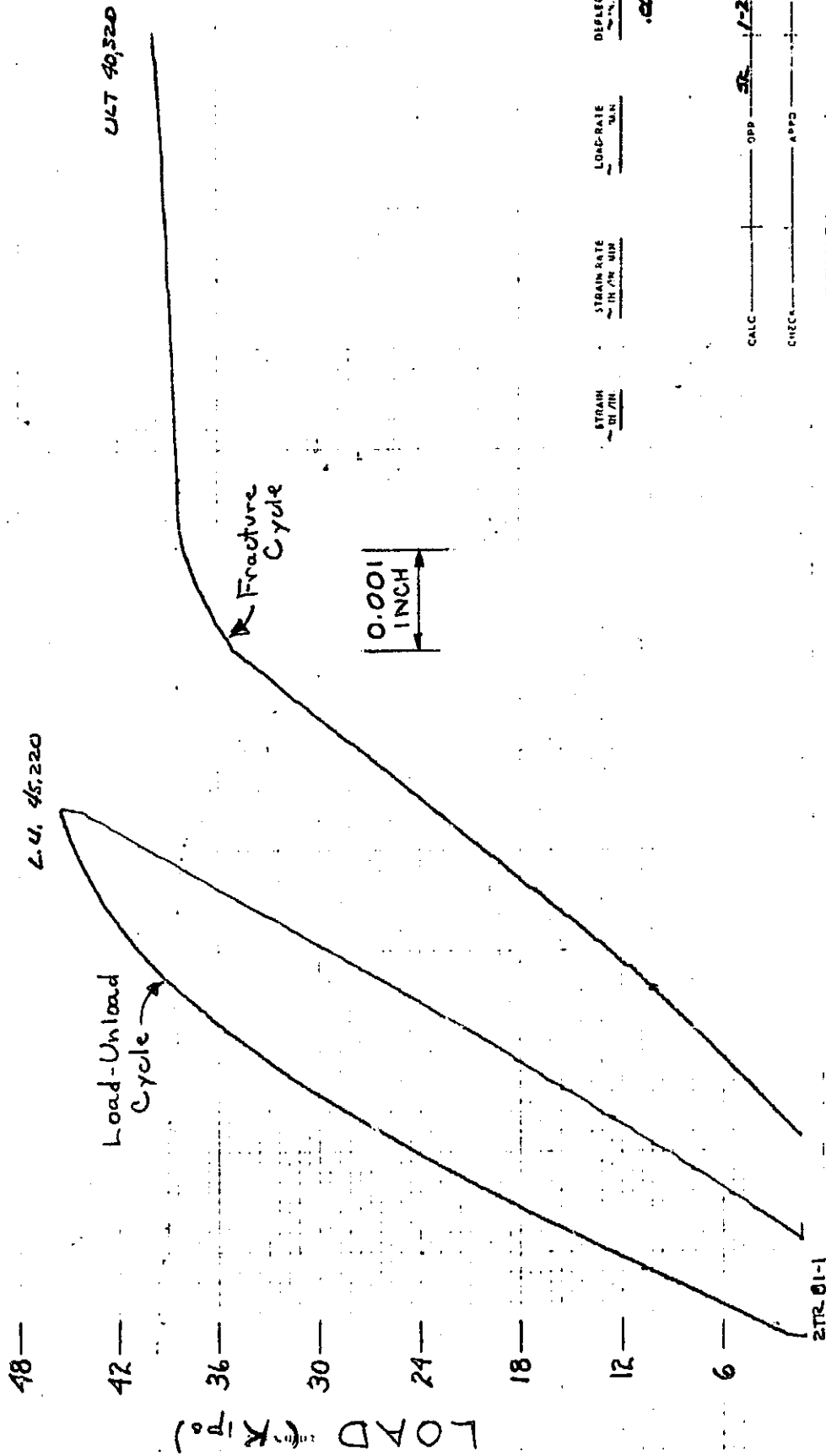
BOEING

PAGE OF

215-347

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR81-1



STRAIN RATE
IN / IN MIN

LOAD RATE
IN / IN MIN

DISPLACEMENT
IN

CALC

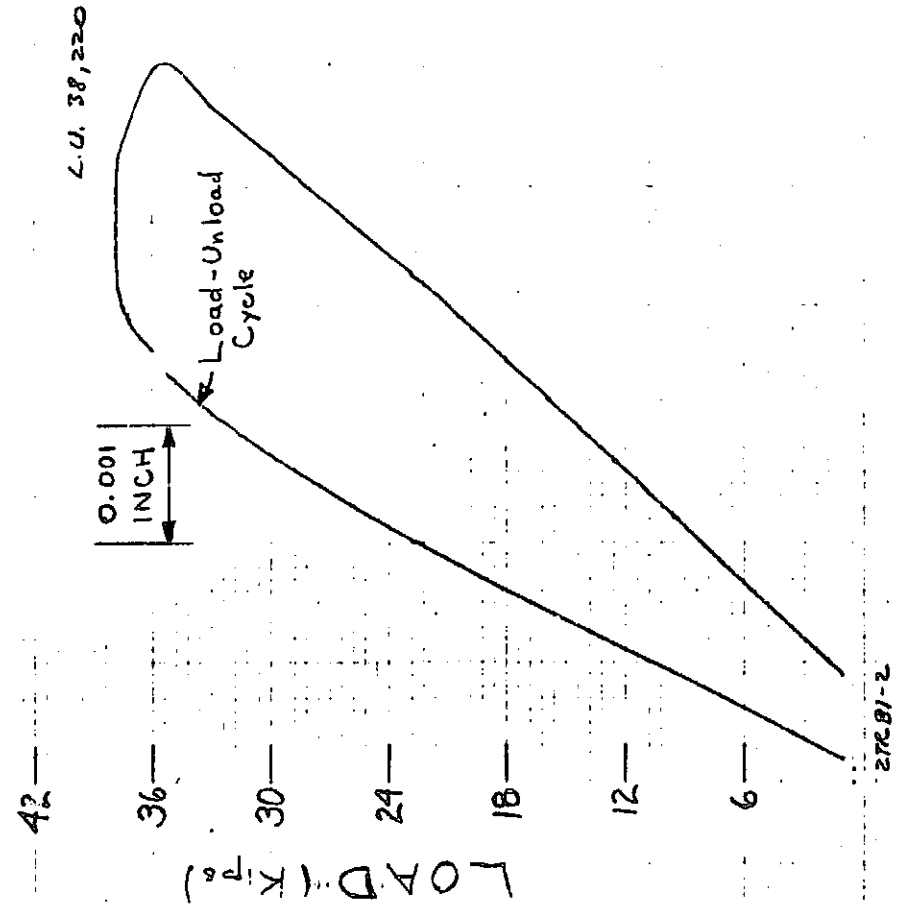
CHECK

DATE

J19-087

REPRODUCIBILITY OF THE
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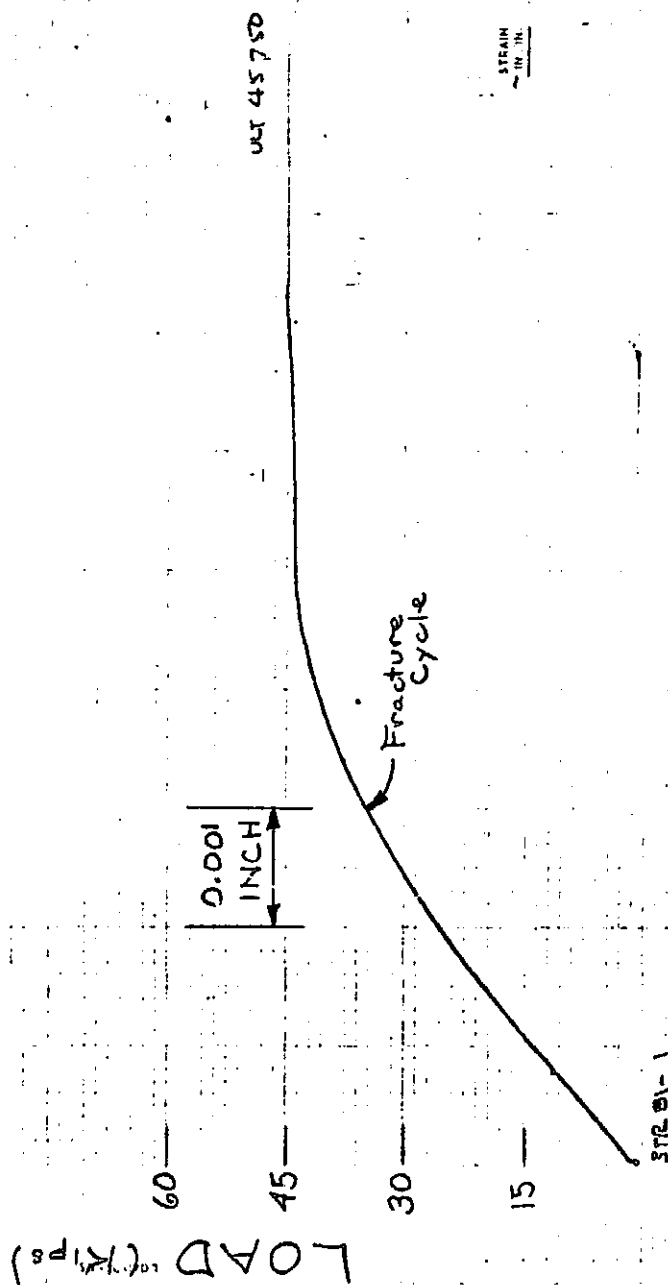
TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 27C81-2



STRAIN RATE
IN/IN MIN
LOAD RATE
LBS/IN MIN
DEFLECTION
IN

CALC
MECH
SPEC
DATE
PAGE

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3TR81-1



STEAM RATE $\frac{IN}{IN \cdot MIN}$ 0.01

LOAD RATE $\frac{KIP}{MIN}$ 0.01

DISPLACEMENT $\frac{IN}{MIN}$ 0.01

CALC 5 1-78-6

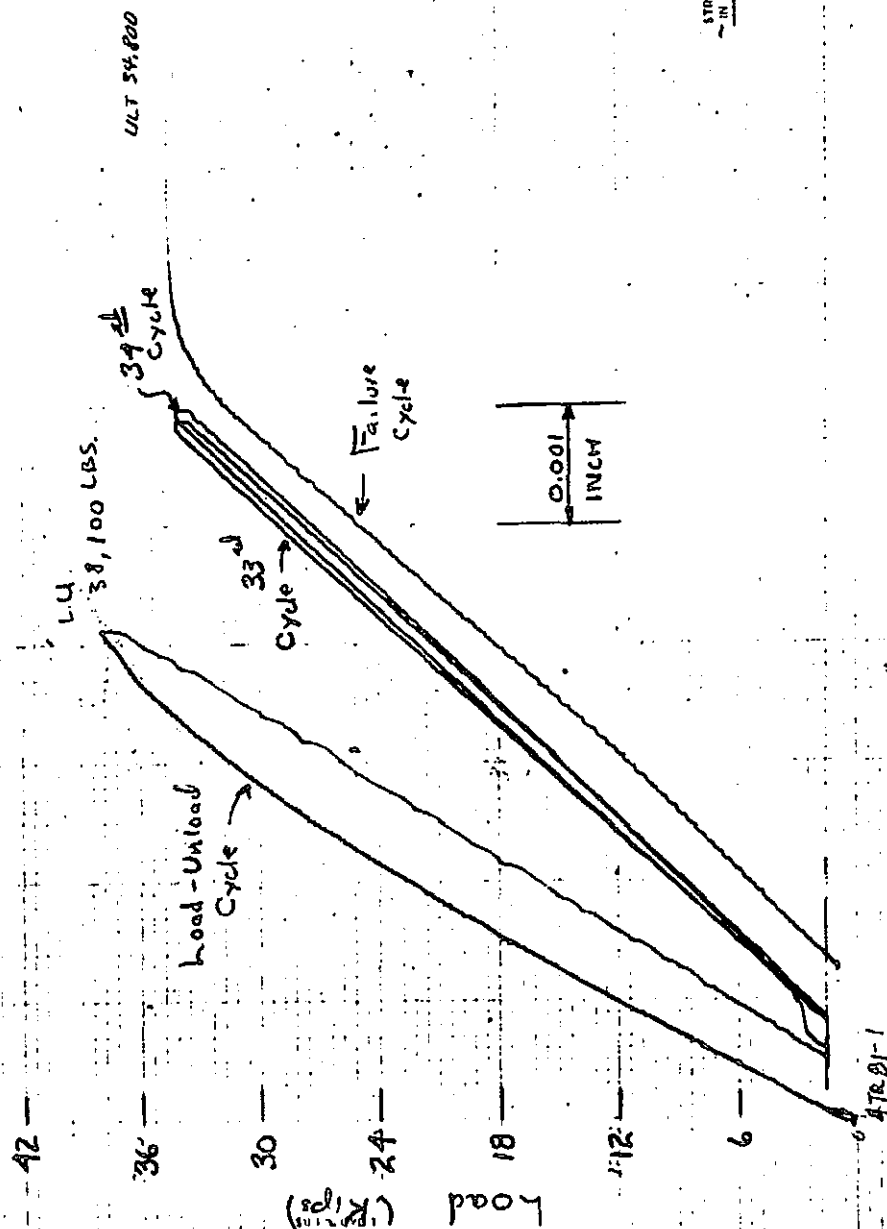
CHECK 5 1-78-6

118-347

BOEING

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4TR81-1



STRAIN RATE
IN IN. / MIN.

LOAD RATE
LBS. / MIN.

SECTION

1001

CALC. ———— DES. ———— SEC. ————
CHECK ———— APPR. ————

516 4-38-6

BOEING

115-001

REVISOR'S NAME

TITANIUM: SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TRB3-1

48 —

42 —

36 —

30 —

24 —

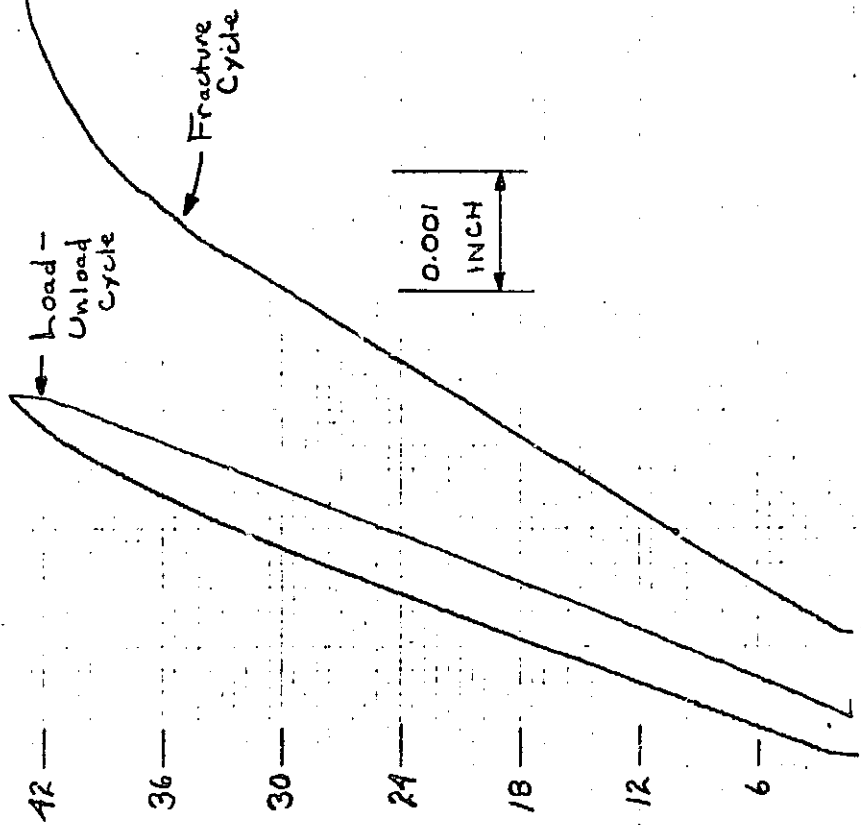
18 —

12 —

6 —

Load (Kips)

ULT 43,140



0.001 INCH

A 3857E OR G. 8/48

STRAIN
IN / IN

STRAIN RATE
IN / IN MIN

LOSS RATE
MIN

DEFLECTION
IN

.001

CALC

CHK

3.22-6

CHECK

APPS

BIDEINS

CF

118-047

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR83-2

ULT 39,000

L.U. 44,160

Load-Unload
Cycle

Intermediate
Cycle

Fracture
Cycle

0.001
INCH

Load (K-
P)

STRAIN
~ IN./IN.
STRAIN RATE
~ IN./IN. MIN.
LOAD RATE
~ LBS./MIN.
DEFLECTION
~ IN.

0.01

CALC. DFR. 39,000 1-30-6

CHECK ASPD

A 10010 ORIG 6/62

JIS-043

BOEING

YPR

ERR

PAGE

OF

2TR83-2

LOAD (KIPS)

60—
45—
30—
15—

0.001
INCH

ULT 44 KSD

Fracture
Cycle

3TR83-1

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3TR83-1

STRAIN
IN IN

STRAIN RATE
IN IN MIN

LOAD RATE
IN IN MIN

DEFLECTION
IN

.001

CALC

CHECK

54—

48—

42—

36—

30—

24—

18—

12—

6—

LOAD (K) 1000 LBS

LU-51/530

← Load-Unload Cycle

← Intermediate Cycle

← Fracture Cycle

0.001 INCH

ULT. 18.890

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2TR84-2

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN	IN/IN	IN
			.001

2TR84-2

CELL --- EXP --- SK. 1-30-6

WICK --- APP ---

8 387E 0910, 8/68

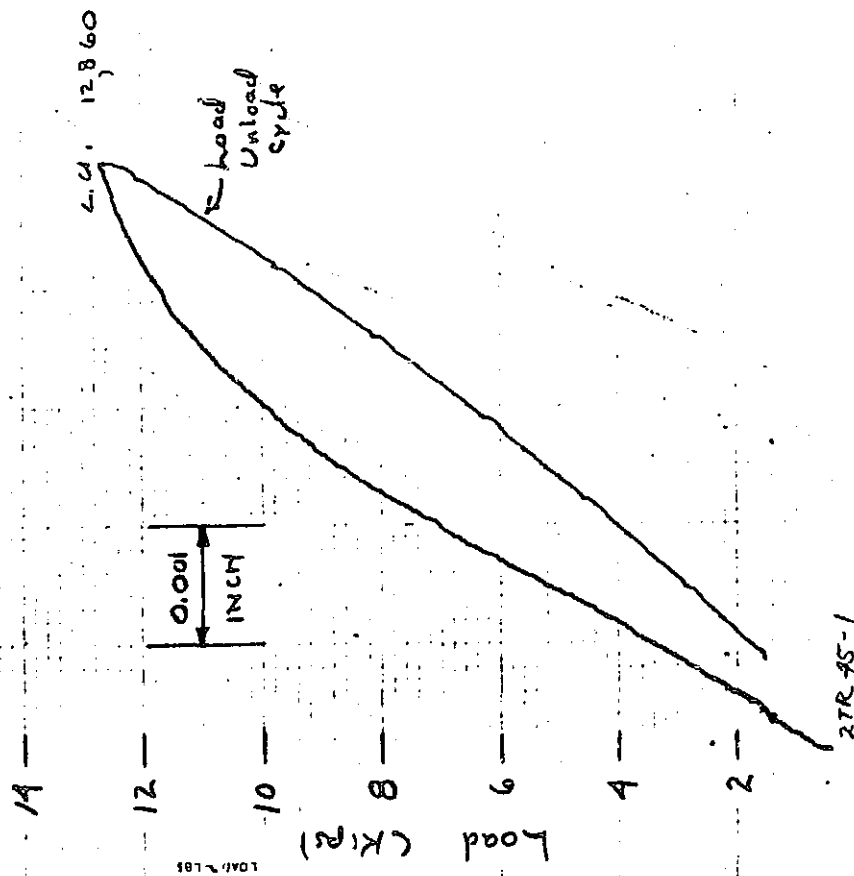
419-047

ENGINE

100
PAGE 51

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR45-1

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



STRAIN RATE
IN./IN. MIN.
LOAD RATE
LBS./MIN.
DEFLECTION
IN.

.001

CALC

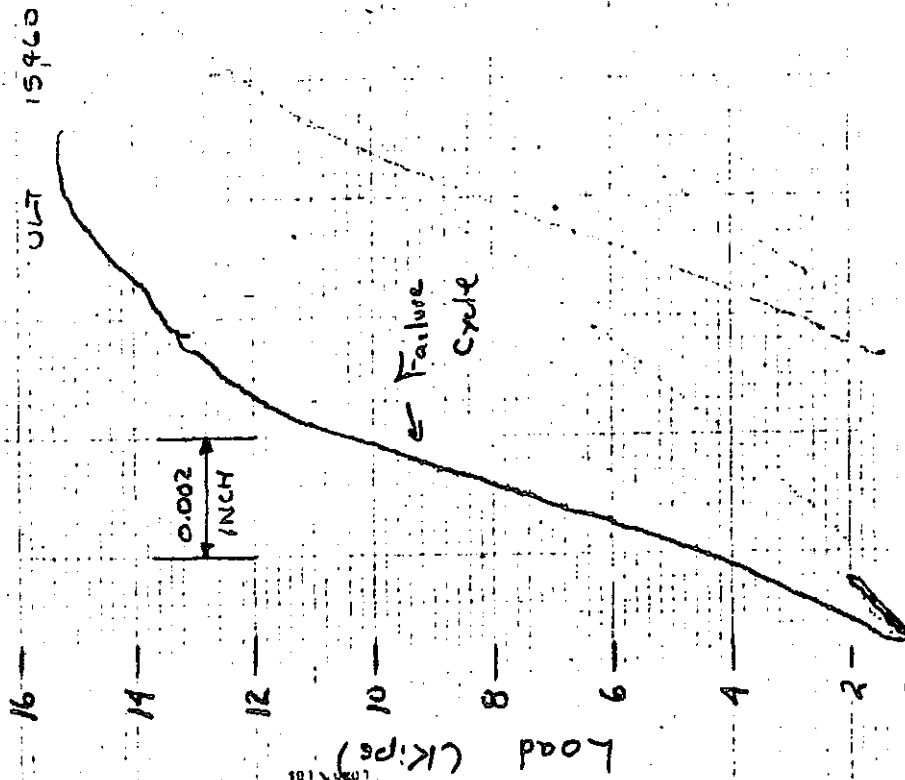
CHECK

REVISION

DATE

318-041

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR45-1



STRAIN RATE
IN/IN/MIN

LOAD RATE
LBS/MIN

DEFLECTION
IN

.002

SCALE

UPD

5/1/6

CHE

APPD

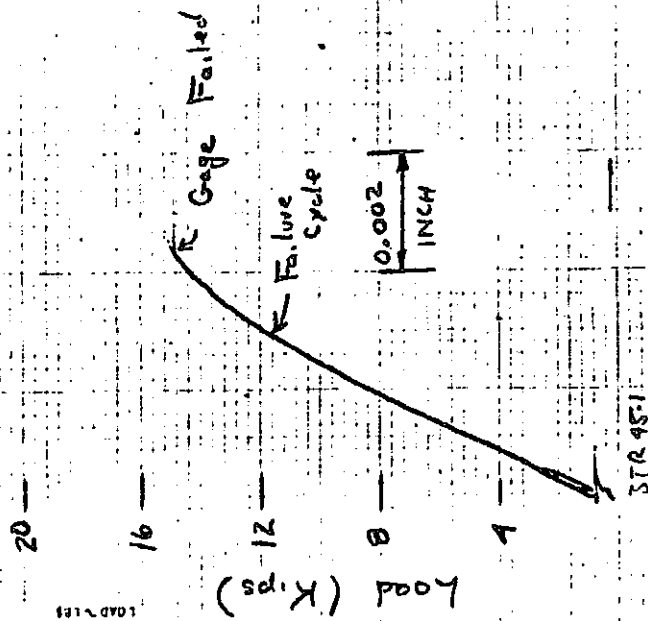
2TR45-1

2TR45-1

2TR45-1

2TR45-1

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3TR45-1



STRAIN RATE
IN./IN./MIN.

LONG RATE
MIN.

SELECTION
1/200

CALC. ———— CDR SL 1-8-6

CHECK ———— APPD ————

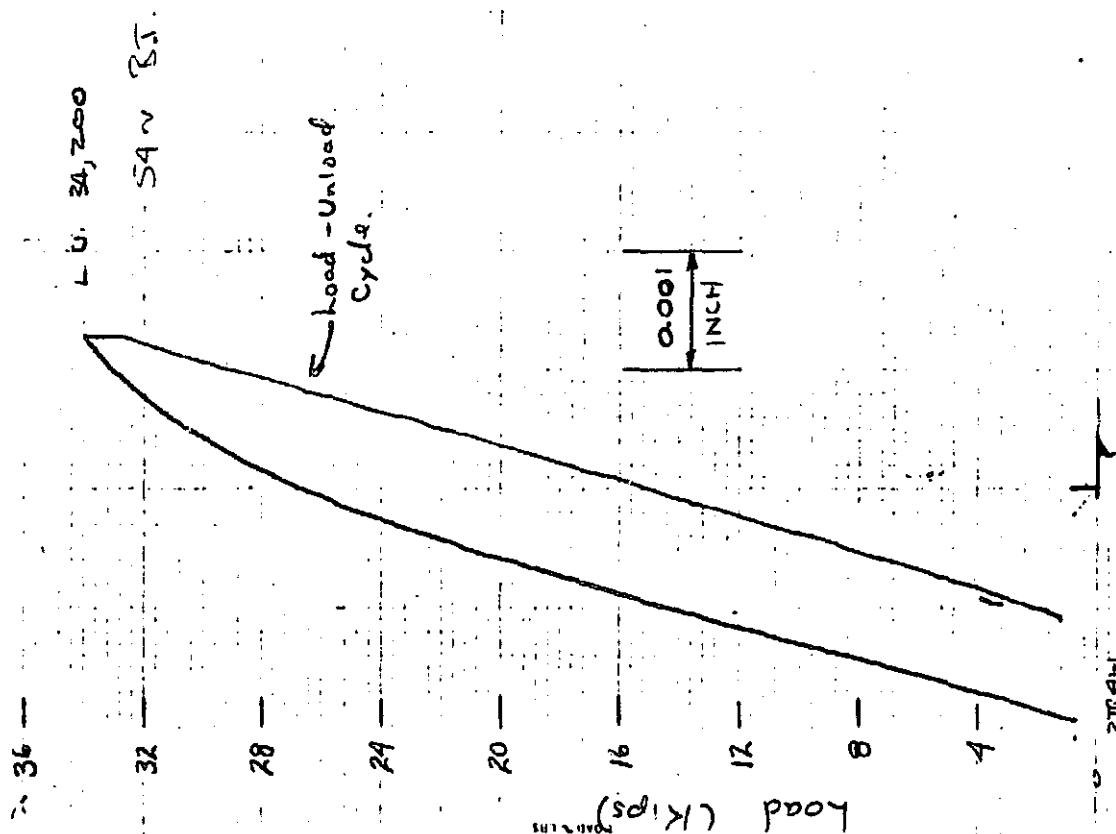
BIDEING 1198

1000

1000

JIS-007

132



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR41-1

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN/IN	IN/IN/SEC	IN/SEC	IN
			0.01

SCALE 0.50 SEC 5.00

CHUCK 1000

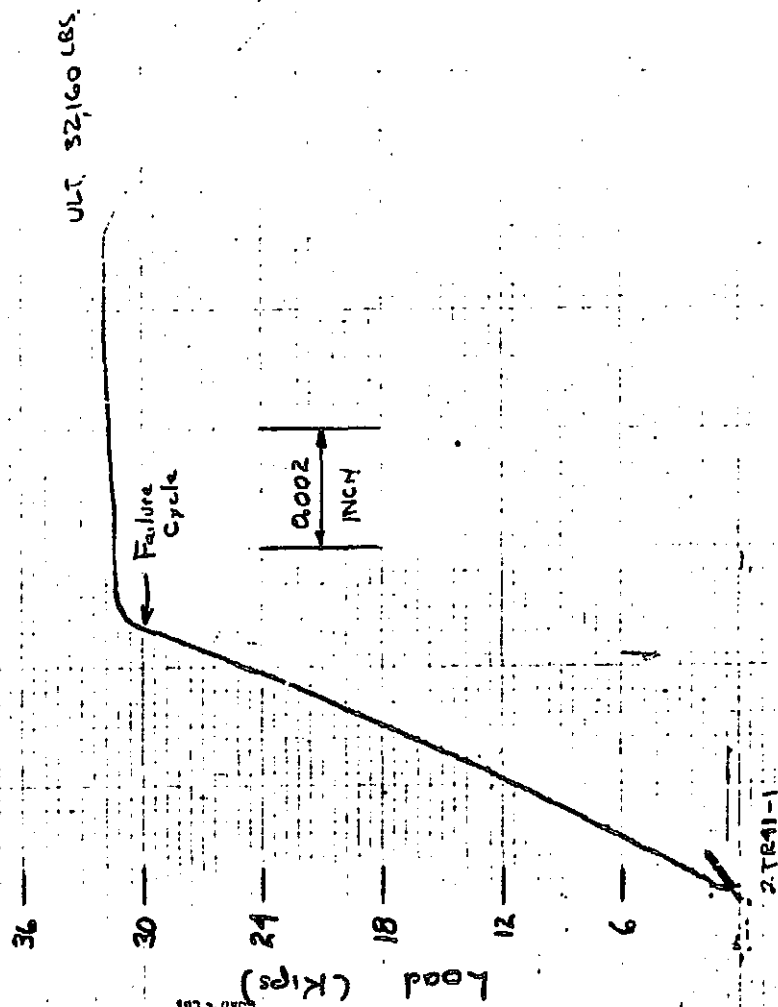
SOEING

418-042

AIR-042

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR41-1



STRAIN RATE
IN./IN./MIN.

LOAD RATE
IN./MIN.

DEFLECTION
IN.

.002

CALC

CHECK

0.00

0.01

0.02

0.03

0.04

0.05

0.06

0.07

0.08

0.09

0.10

219-007

219-007

BOEING

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

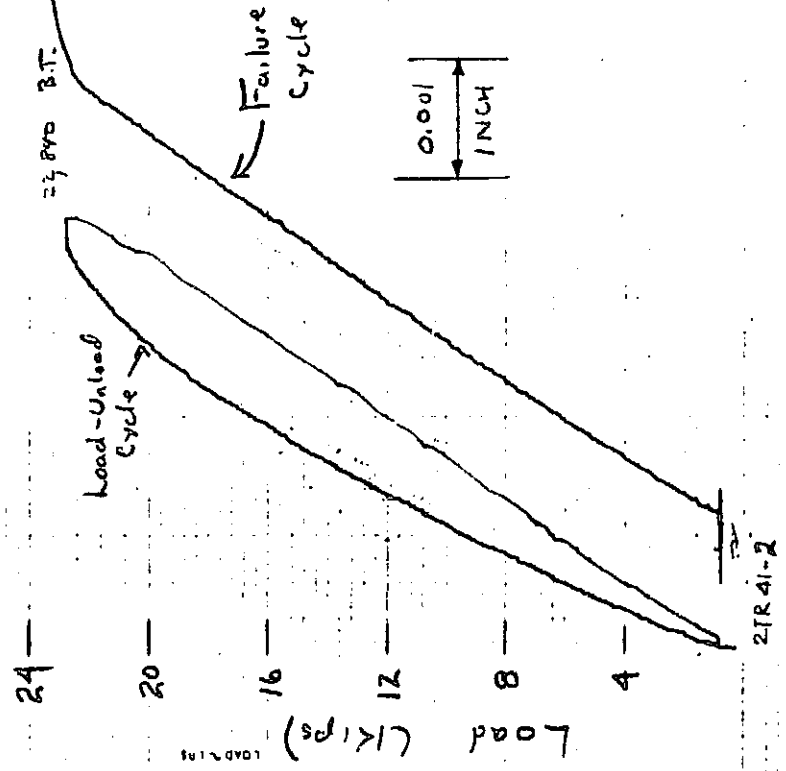
100

100

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR41-2

ULT 24080



STRAIN RATE
MIN IN IN MIN

LOAD RATE
MIN IN IN MIN

DISPLACEMENT
MIN IN IN

.001

CALC

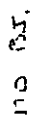
CHECK

ENDING

J18-002

2 TR41-2

Specimen 3TR41-1



Failure
cycle.

0.001 INCH

37841-1

— 11978 20:0 1503

418-0441

3NF37B

703

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN / IN.	IN. / IN.	IN. / IN.	IN.
0.000	0.000	0.000	0.000
0.001	0.001	0.001	0.001
0.002	0.002	0.002	0.002
0.003	0.003	0.003	0.003
0.004	0.004	0.004	0.004
0.005	0.005	0.005	0.005
0.006	0.006	0.006	0.006
0.007	0.007	0.007	0.007
0.008	0.008	0.008	0.008
0.009	0.009	0.009	0.009
0.010	0.010	0.010	0.010
0.011	0.011	0.011	0.011
0.012	0.012	0.012	0.012
0.013	0.013	0.013	0.013
0.014	0.014	0.014	0.014
0.015	0.015	0.015	0.015
0.016	0.016	0.016	0.016
0.017	0.017	0.017	0.017
0.018	0.018	0.018	0.018
0.019	0.019	0.019	0.019
0.020	0.020	0.020	0.020
0.021	0.021	0.021	0.021
0.022	0.022	0.022	0.022
0.023	0.023	0.023	0.023
0.024	0.024	0.024	0.024
0.025	0.025	0.025	0.025
0.026	0.026	0.026	0.026
0.027	0.027	0.027	0.027
0.028	0.028	0.028	0.028
0.029	0.029	0.029	0.029
0.030	0.030	0.030	0.030
0.031	0.031	0.031	0.031
0.032	0.032	0.032	0.032
0.033	0.033	0.033	0.033
0.034	0.034	0.034	0.034
0.035	0.035	0.035	0.035
0.036	0.036	0.036	0.036
0.037	0.037	0.037	0.037
0.038	0.038	0.038	0.038
0.039	0.039	0.039	0.039
0.040	0.040	0.040	0.040
0.041	0.041	0.041	0.041
0.042	0.042	0.042	0.042
0.043	0.043	0.043	0.043
0.044	0.044	0.044	0.044
0.045	0.045	0.045	0.045
0.046	0.046	0.046	0.046
0.047	0.047	0.047	0.047
0.048	0.048	0.048	0.048
0.049	0.049	0.049	0.049
0.050	0.050	0.050	0.050
0.051	0.051	0.051	0.051
0.052	0.052	0.052	0.052
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0.054	0.054	0.054	0.054
0.055	0.055	0.055	0.055
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0.057	0.057	0.057	0.057
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0.059	0.059	0.059	0.059
0.060	0.060	0.060	0.060
0.061	0.061	0.061	0.061
0.062	0.062	0.062	0.062
0.063	0.063	0.063	0.063
0.064	0.064	0.064	0.064
0.065	0.065	0.065	0.065
0.066	0.066	0.066	0.066
0.067	0.067	0.067	0.067
0.068	0.068	0.068	0.068
0.069	0.069	0.069	0.069
0.070	0.070	0.070	0.070
0.071	0.071	0.071	0.071
0.072	0.072	0.072	0.072
0.073	0.073	0.073	0.073
0.074	0.074	0.074	0.074
0.075	0.075	0.075	0.075
0.076	0.076	0.076	0.076
0.077	0.077	0.077	0.077
0.078	0.0		

STRAIN RATE
~ 10³ IN. IN. MIN

7040847

DECLASSIFIED

8.

CALC -

54

22-51

82347

— 644 —

1.

7N1-3708
b4,1

703

1

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4TR41-1

ULT 31640

L.U. 21520

32

28

24

20

16

12

8

4

Load-Unload
Cycle

Failure
Cycle

0.001
INCH

LOAD (KIPS.)

4TR 41-1

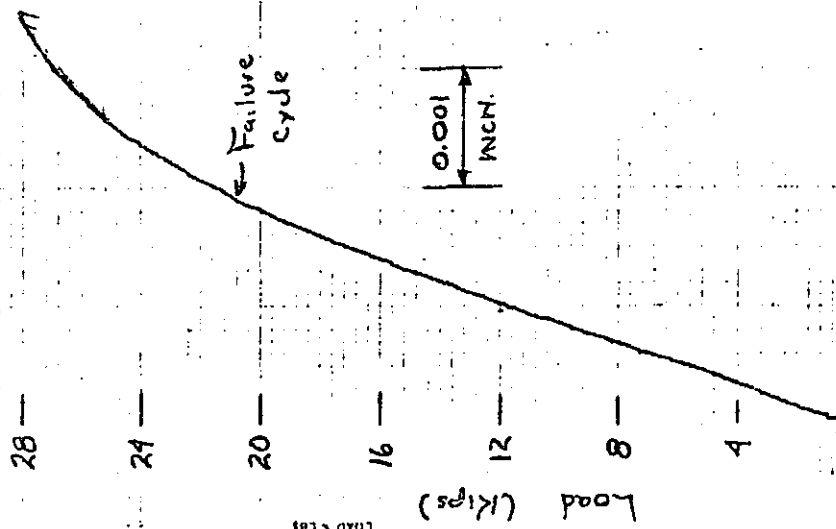
STRAIN
~ 10⁻⁶ IN./IN.
STRAIN RATE
~ 10⁻⁴ IN./IN./MIN.
LOAD RATE
~ 10⁻⁴ KIPS./MIN.
DEFLECTION
~ 0.001

CALC. 216 5-12-6

CHECKED

DATE

5. NOTE ON C. 1742



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4TR41-2

STRAIN IN IN	STRAIN RATE IN IN MIN	LOAD RATE KIP MIN	DEFLECTION IN
			.031

CALC — OPP — 2 — 138-C
CMC — 1000

BOEING

118-247

118-247

32 —

28 —

24 —

20 —

16 —

12 —

8 —

4 —

2TR43-1

L.U. 29120

Load-Unload
Cycle

Failure
Cycle

0.001
INCH

ULT 26,880

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR43-1

REPRODUCIBILITY OF THE
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STRAIN RATE $\frac{IN}{IN \cdot MIN}$ _____
LOAD RATE $\frac{LBS}{MIN}$ _____
DEFLECTION $\frac{IN}{IN}$.001

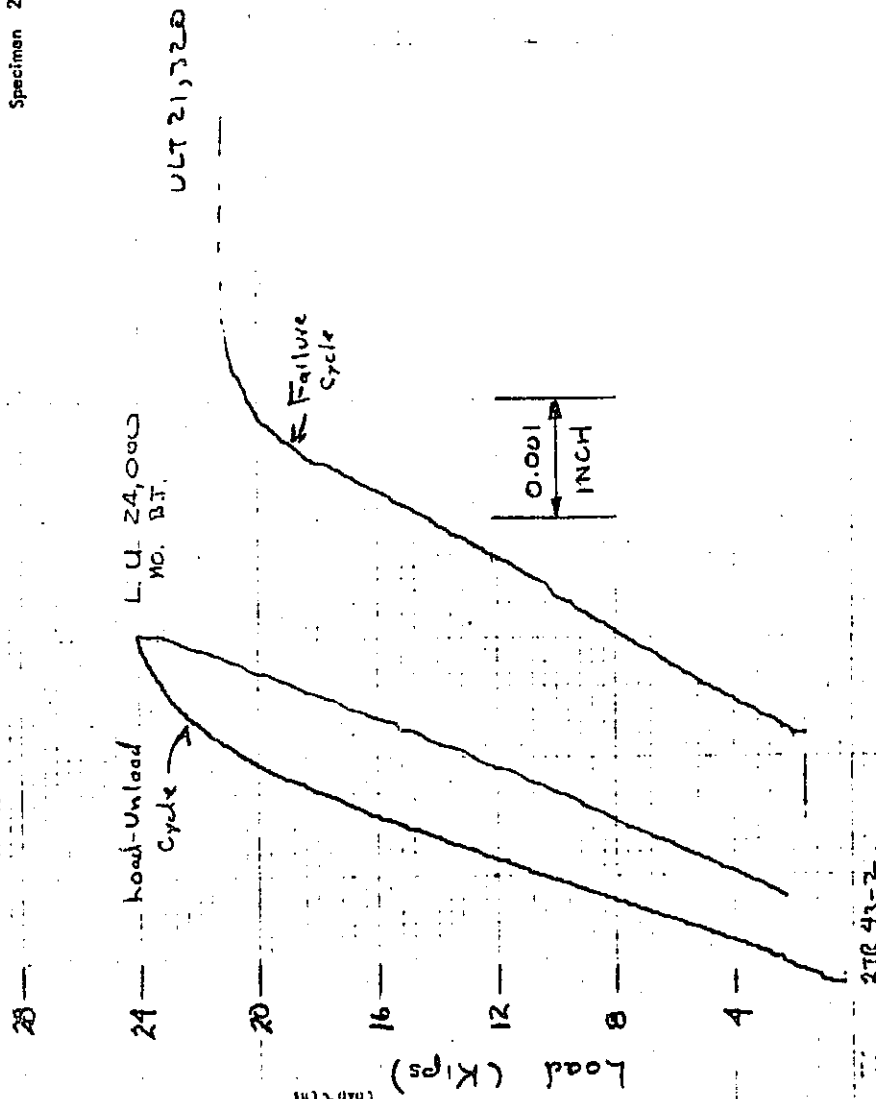
71

DATE _____

CHECK _____

OPENING _____

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR43-2



STRAIN IN/IN
STRAIN RATE IN/IN MIN
LOAD RATE LBS/IN
DEFLECTION IN/IN

CALC. 056 SK 5-12-5
CHECK APPG

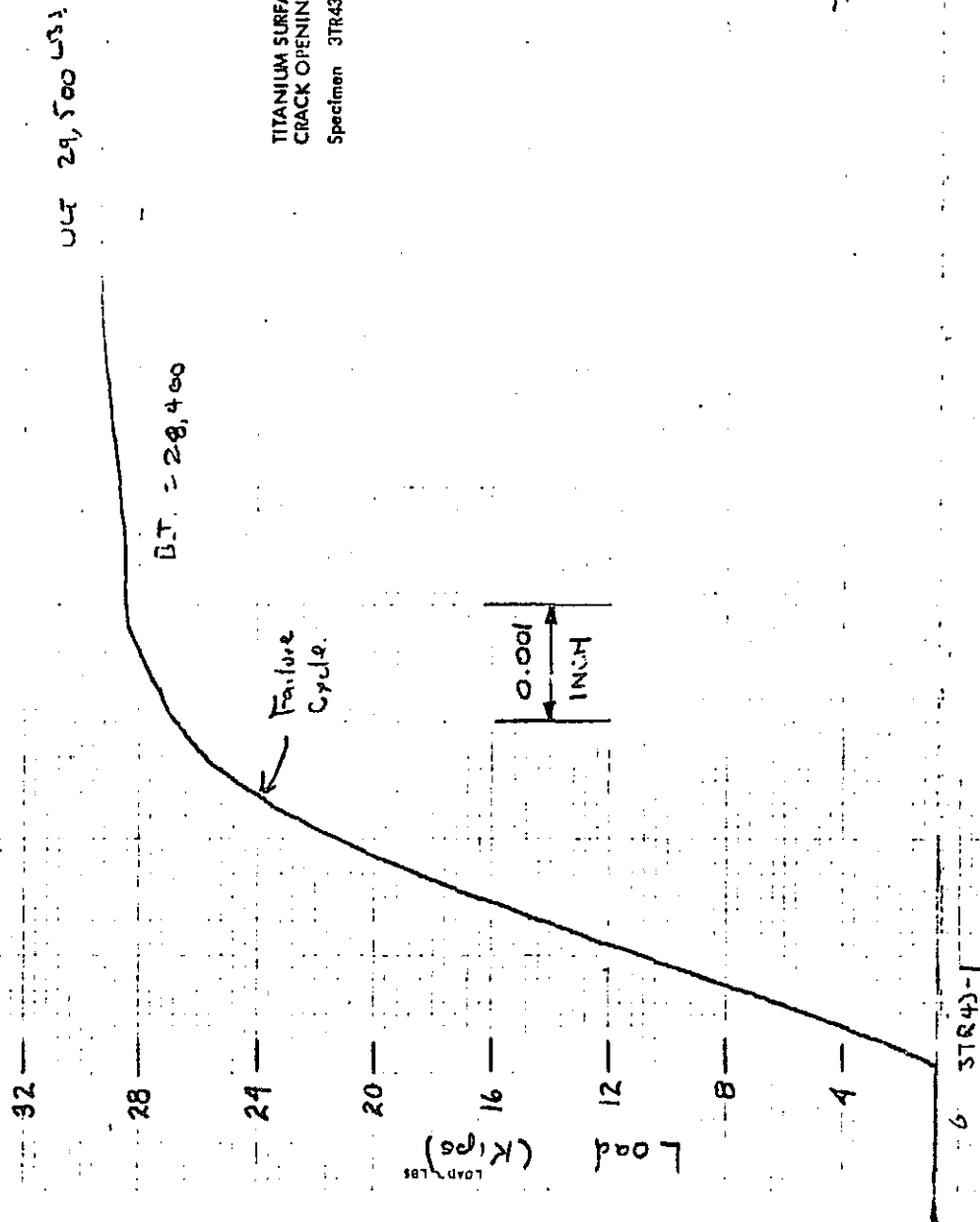
BOEING TYPE

J16-007

2 TR43-2

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3TR43-1



STRAIN \sim IN/IN

STRAIN RATE \sim IN/IN/IN

LOAD RATE \sim IN/IN

DEFLECTION \sim IN

.001

CALC. --- OFF --- 3K 5-P-6

CHECK --- APPE ---

RECORD FOR

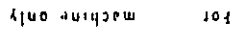
JIR-001

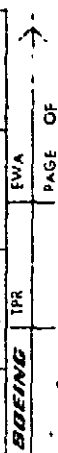
DATE ORG. 8/74

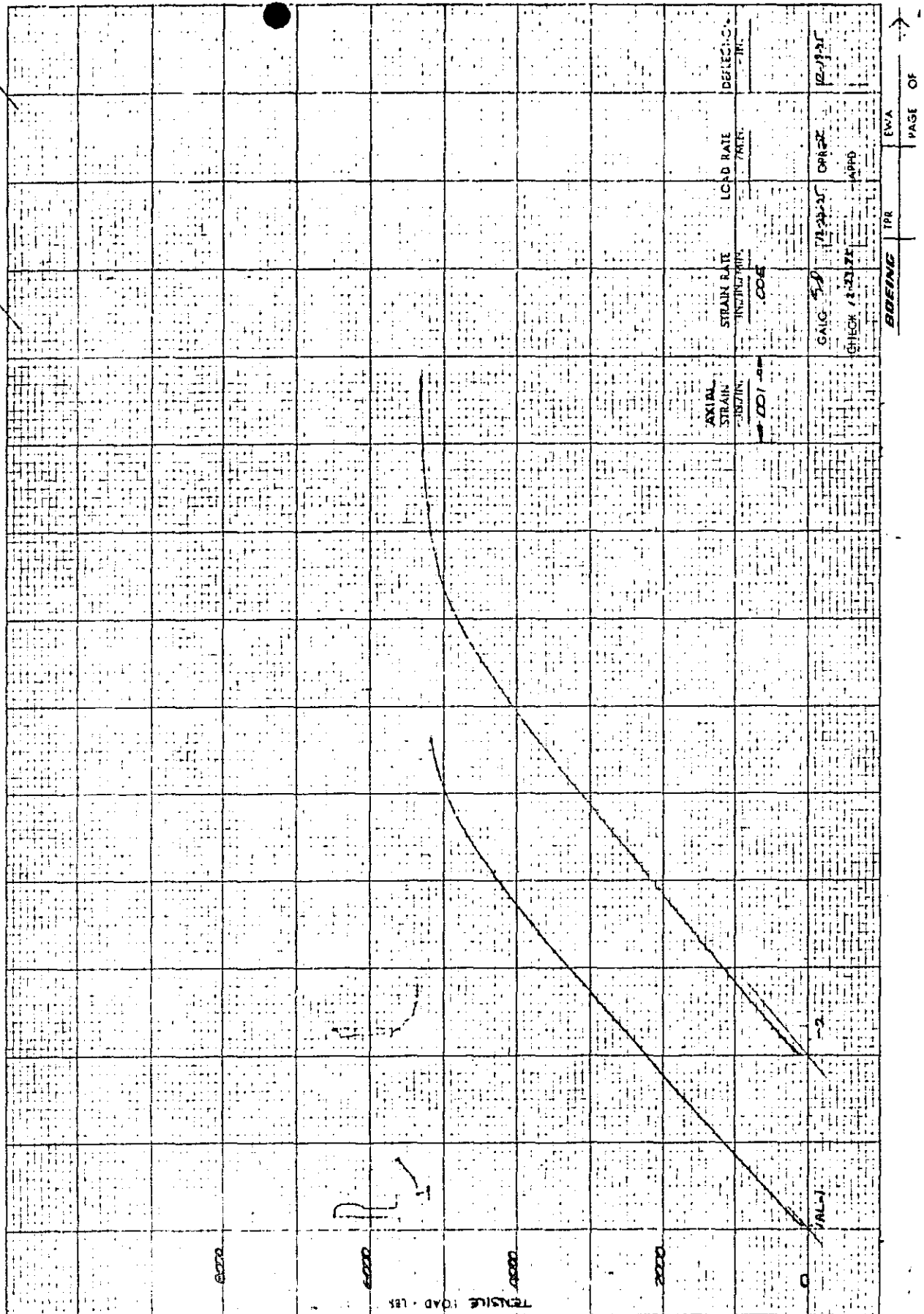
APPENDIX III - Extensometer and Strain Gage Records

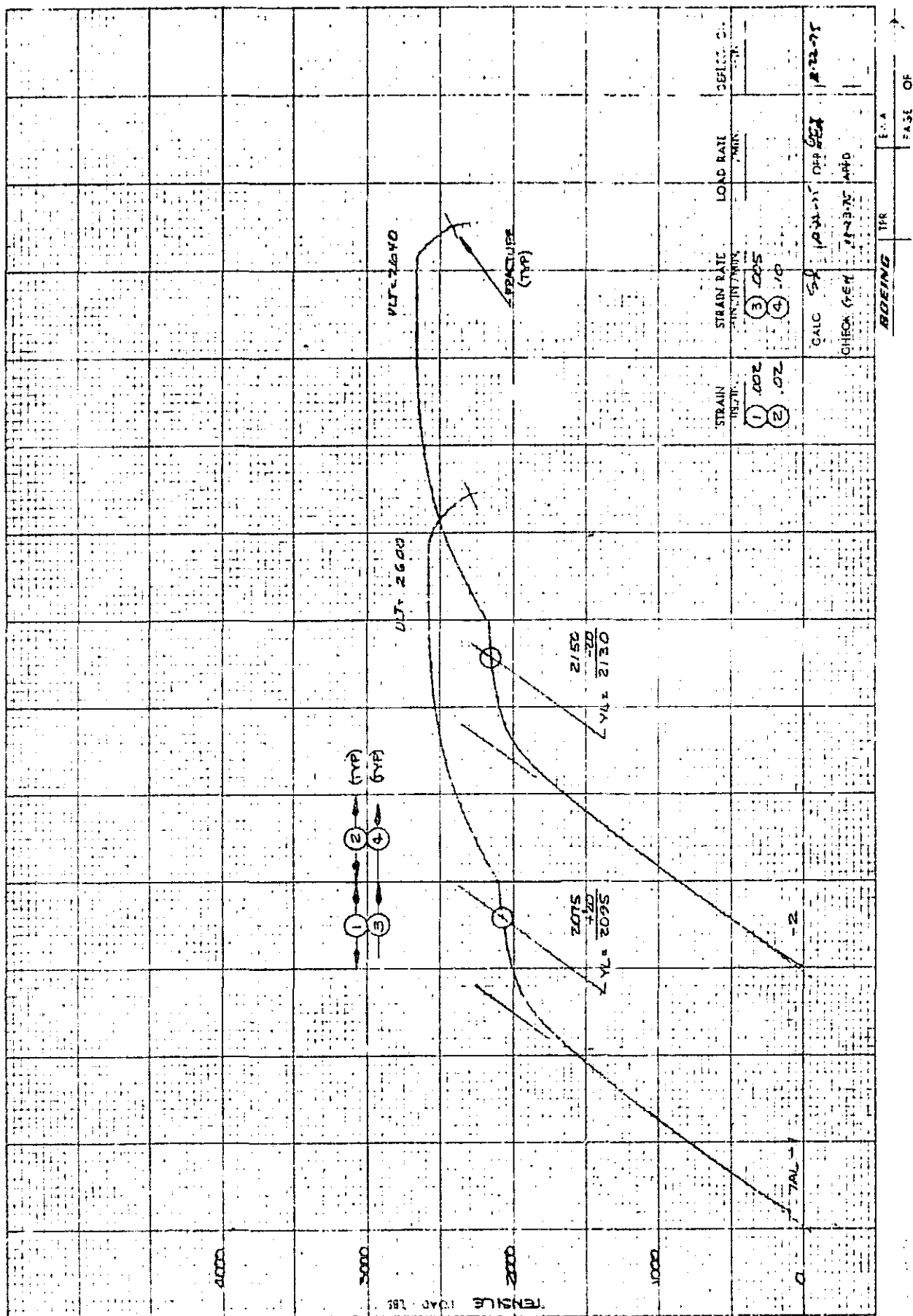
	<u>Page</u>
Extensometer and Strain Gage Records for the Specimens Presented in Table 2 of Vol. I. CR-135369	143-154
Extensometer and Strain Gage Records for the Specimens Presented in Table 3 of Vol. I. CR-135369	155-178
Extensometer and Strain Gage Records for the Specimens Presented in Table 4 of Vol. I. CR-135369.	179-209

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

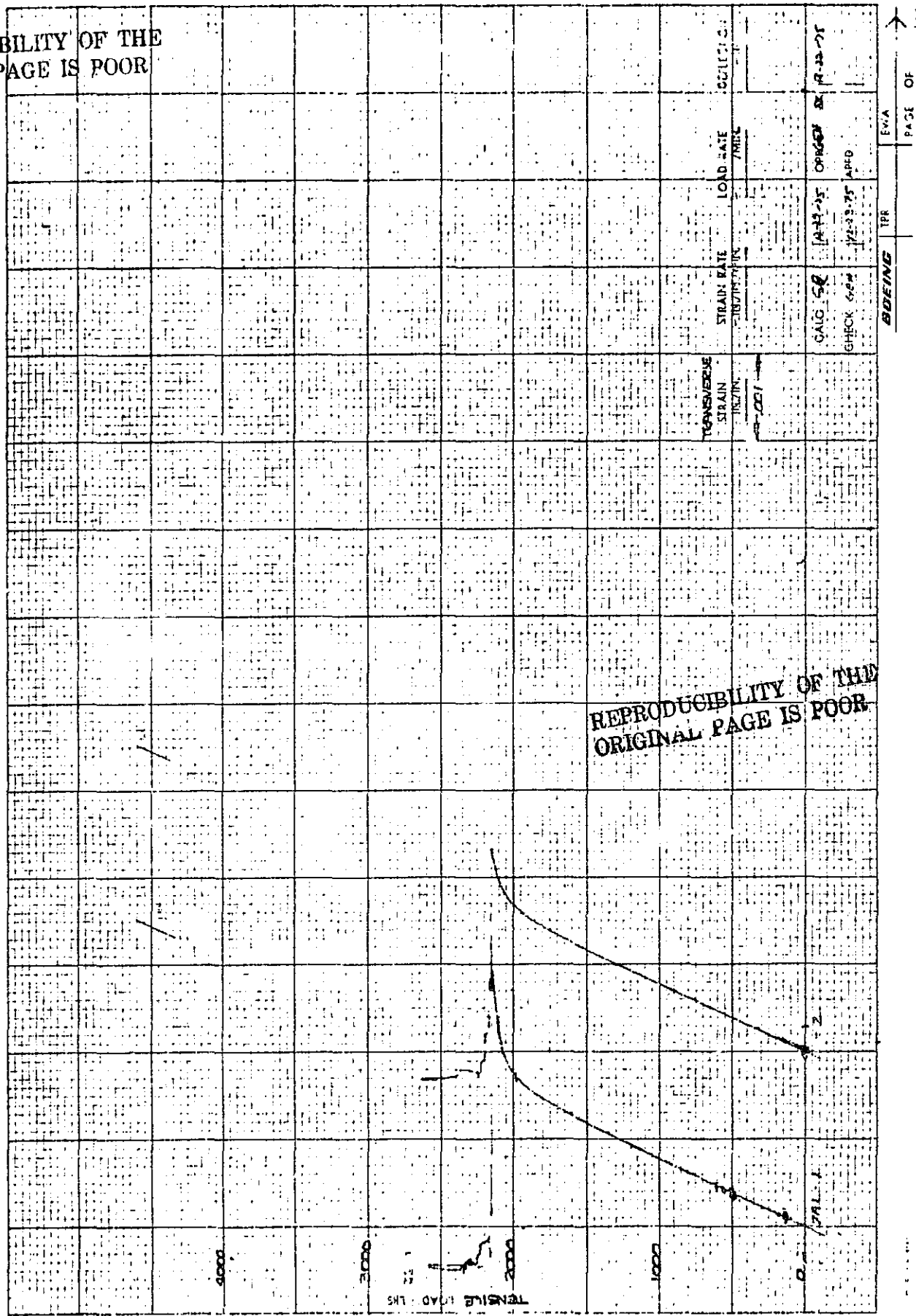


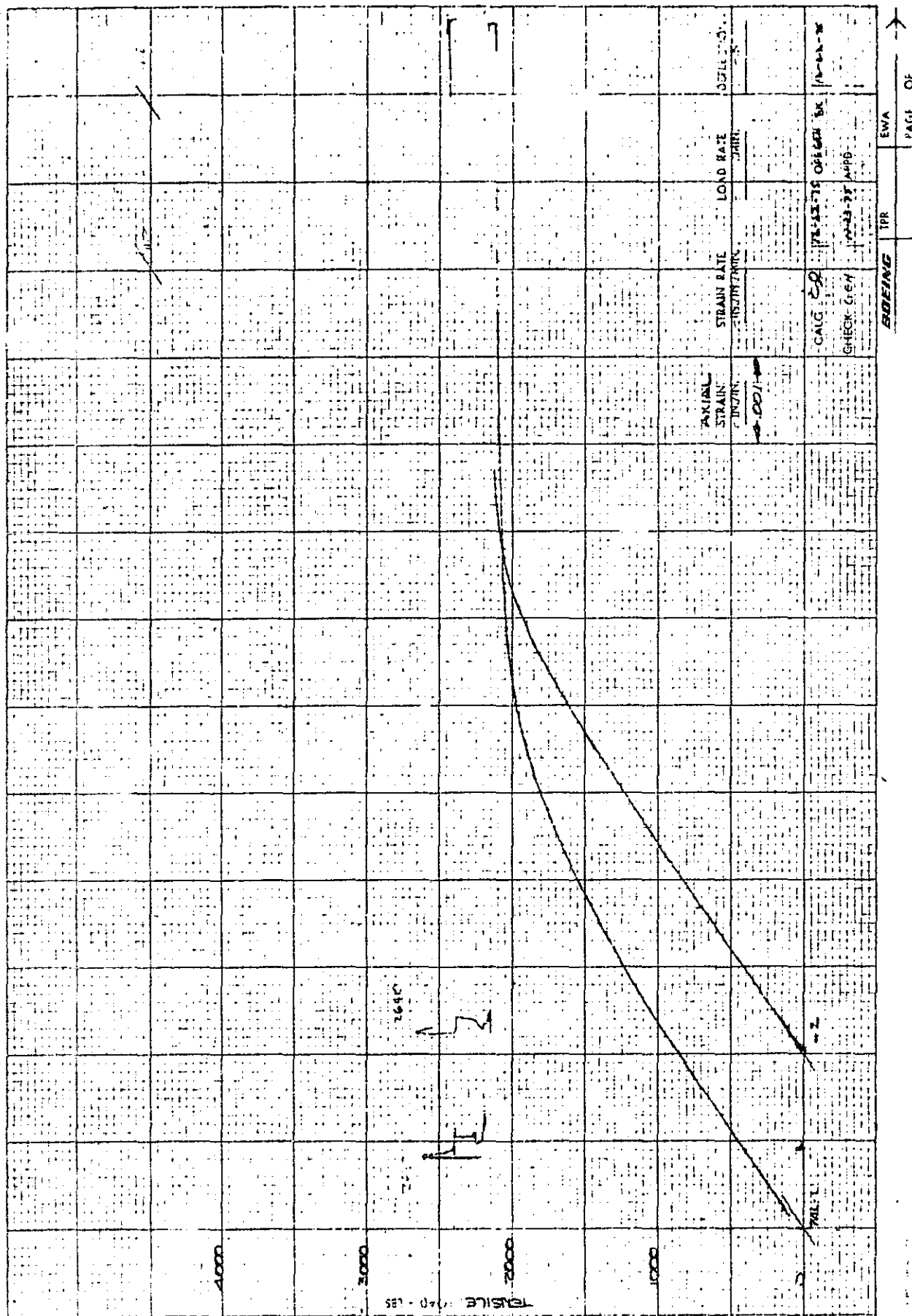




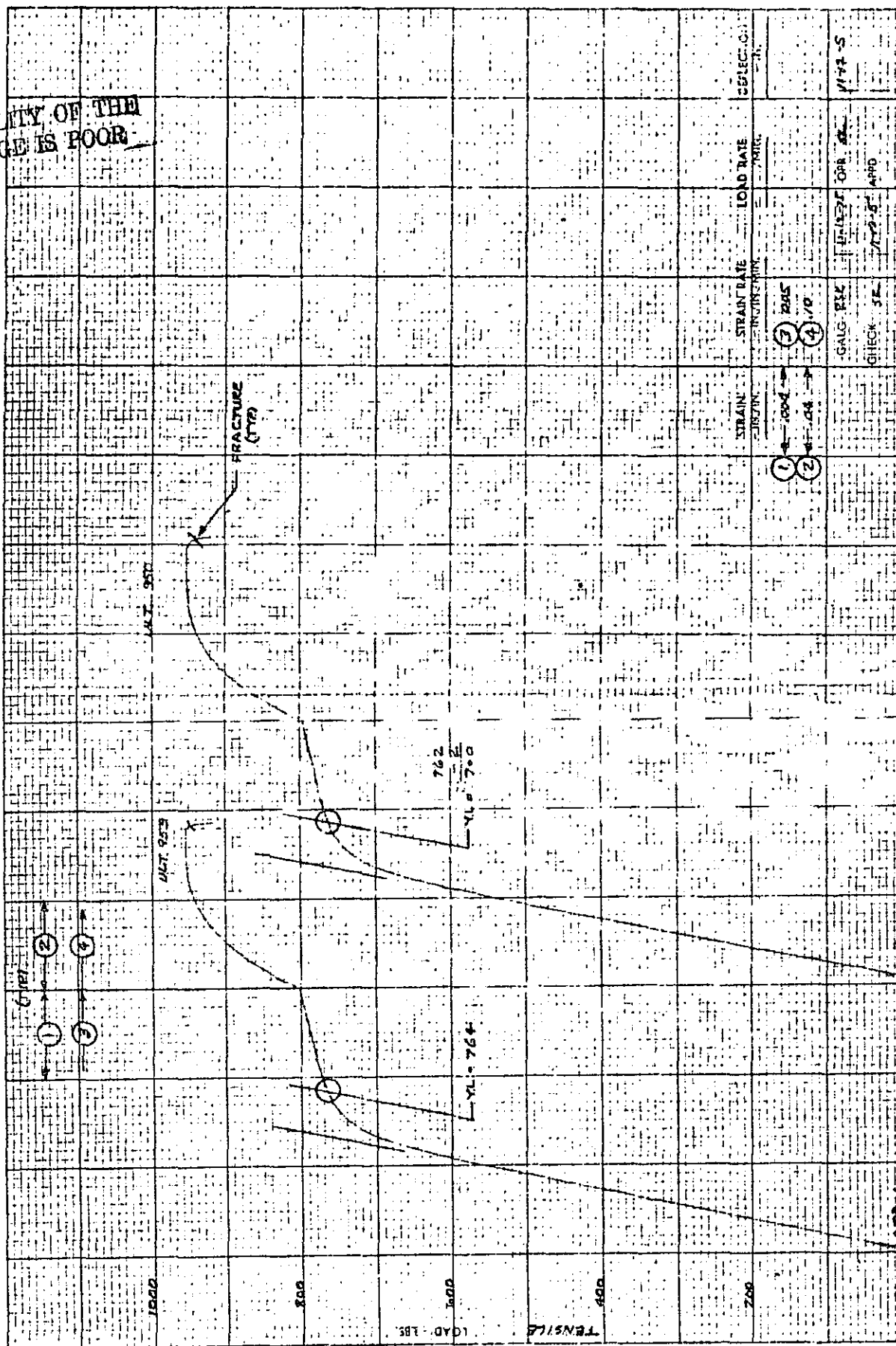


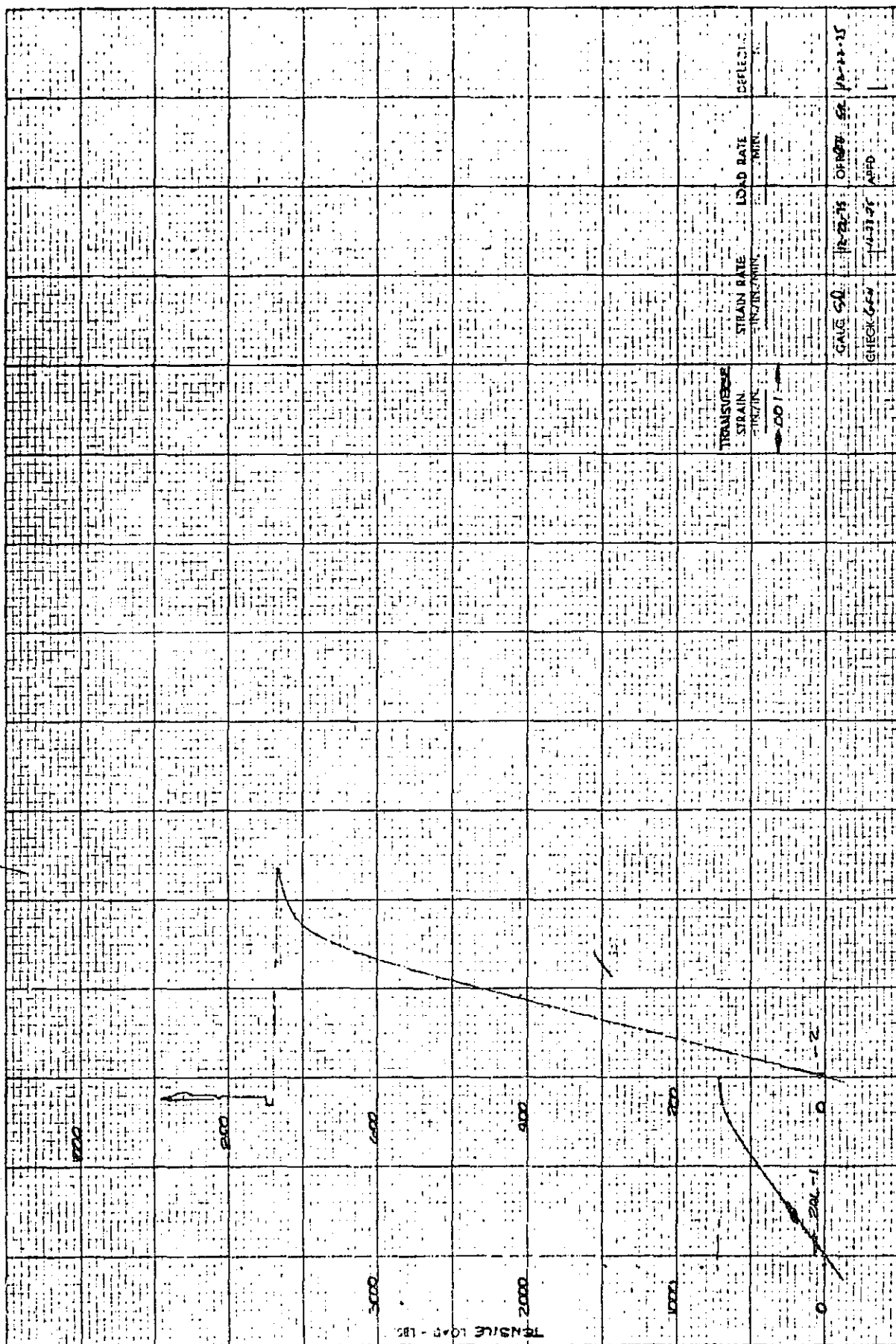
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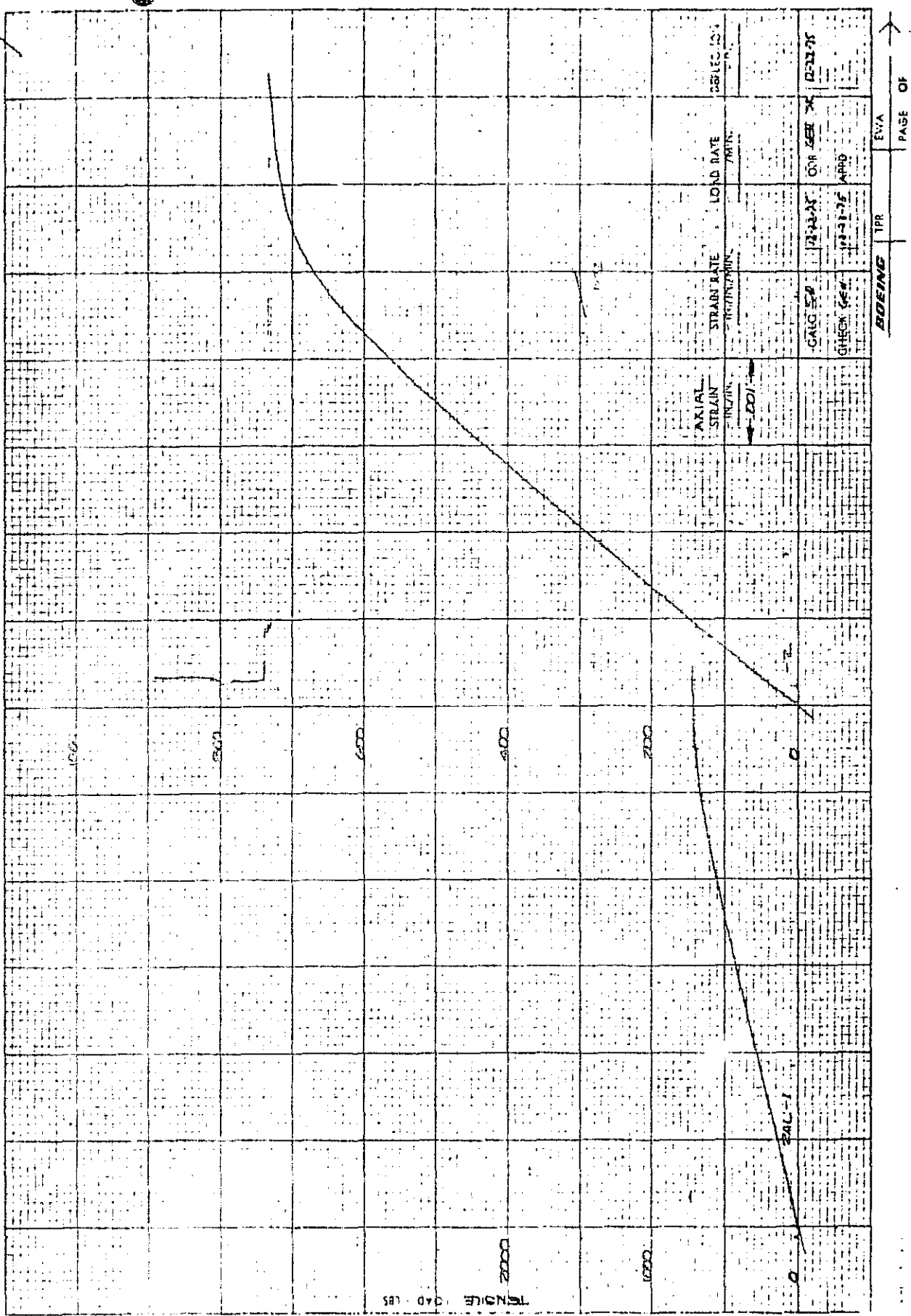




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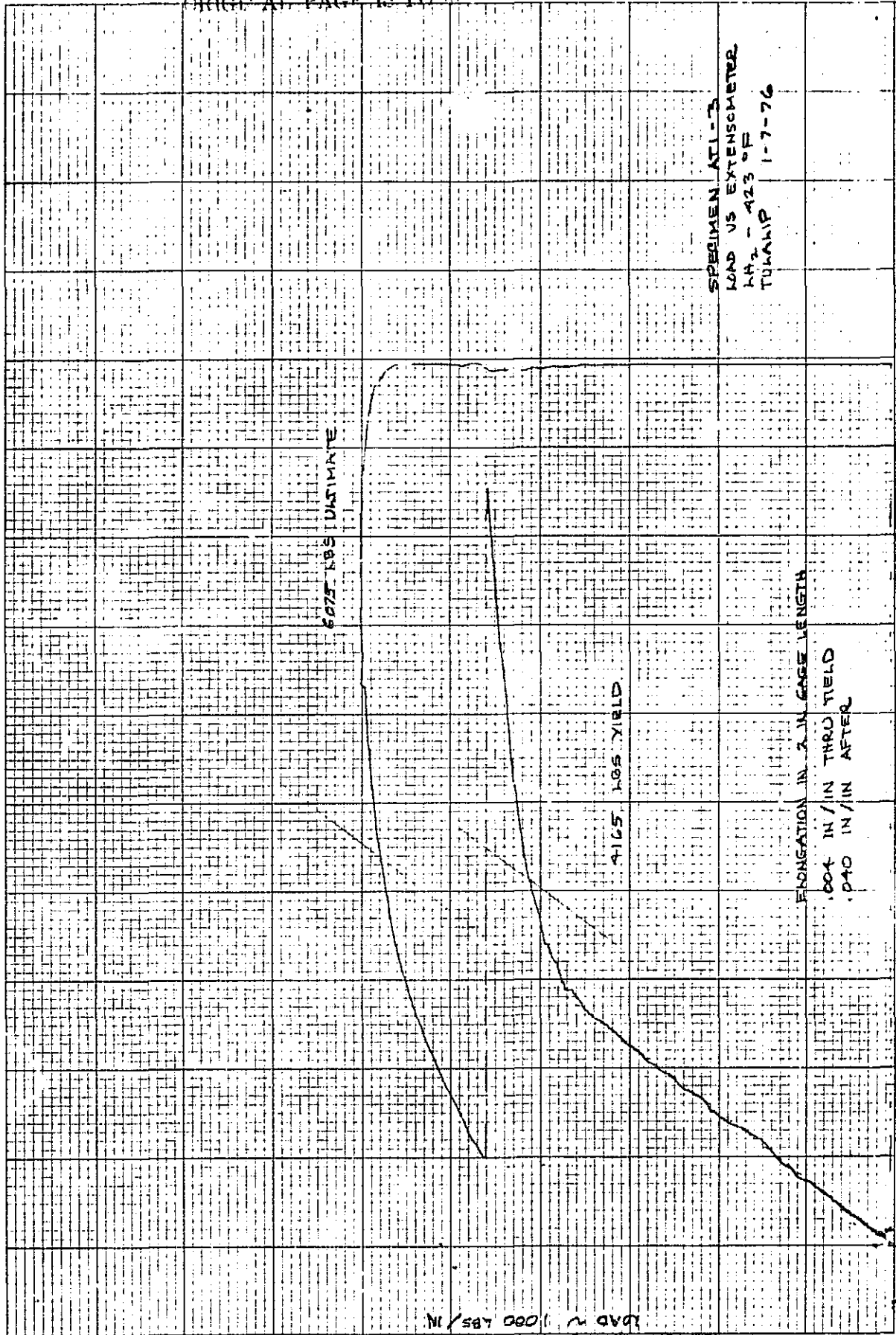


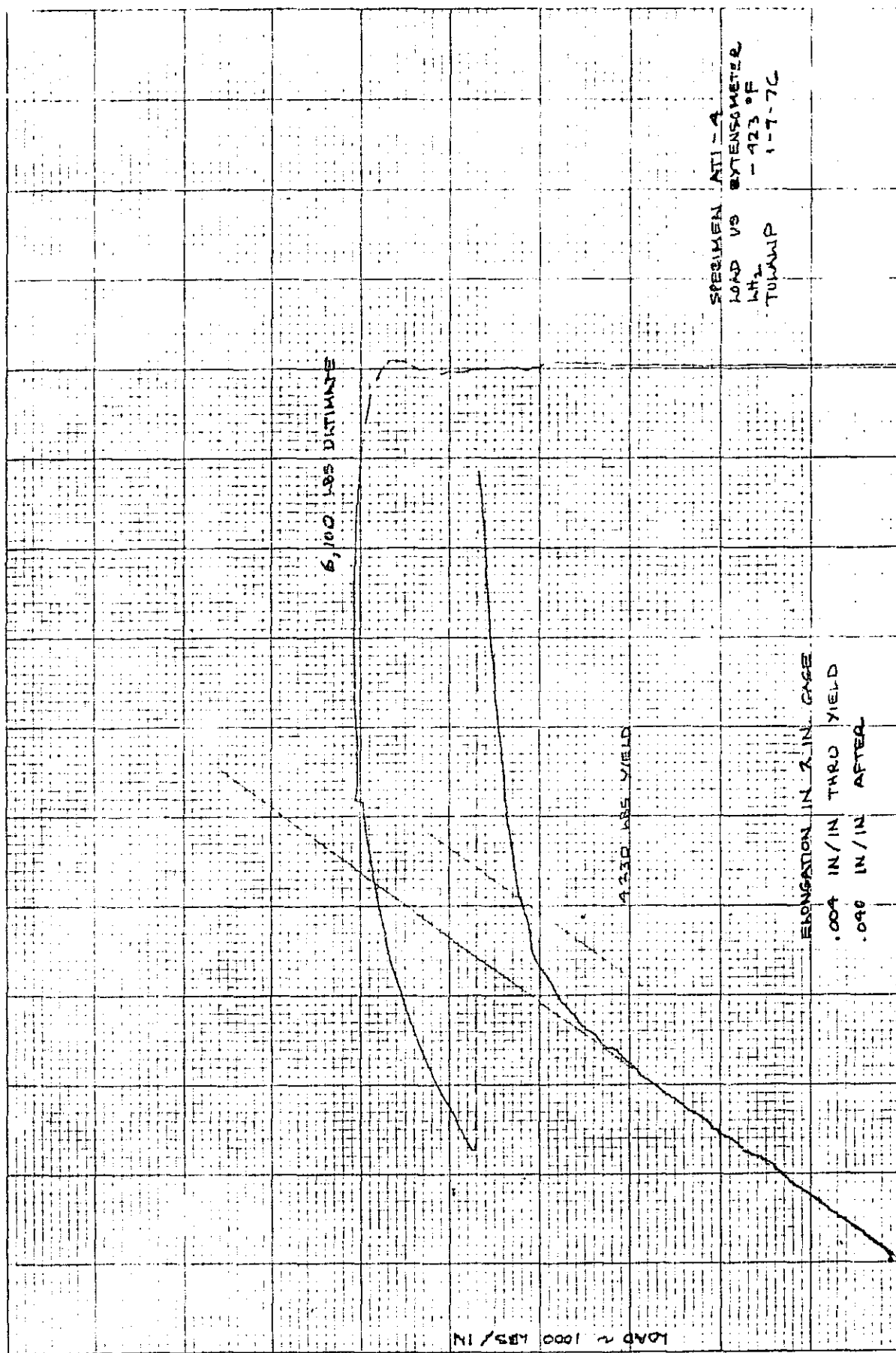




BOEING TPR
EVA
PAGE OF

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



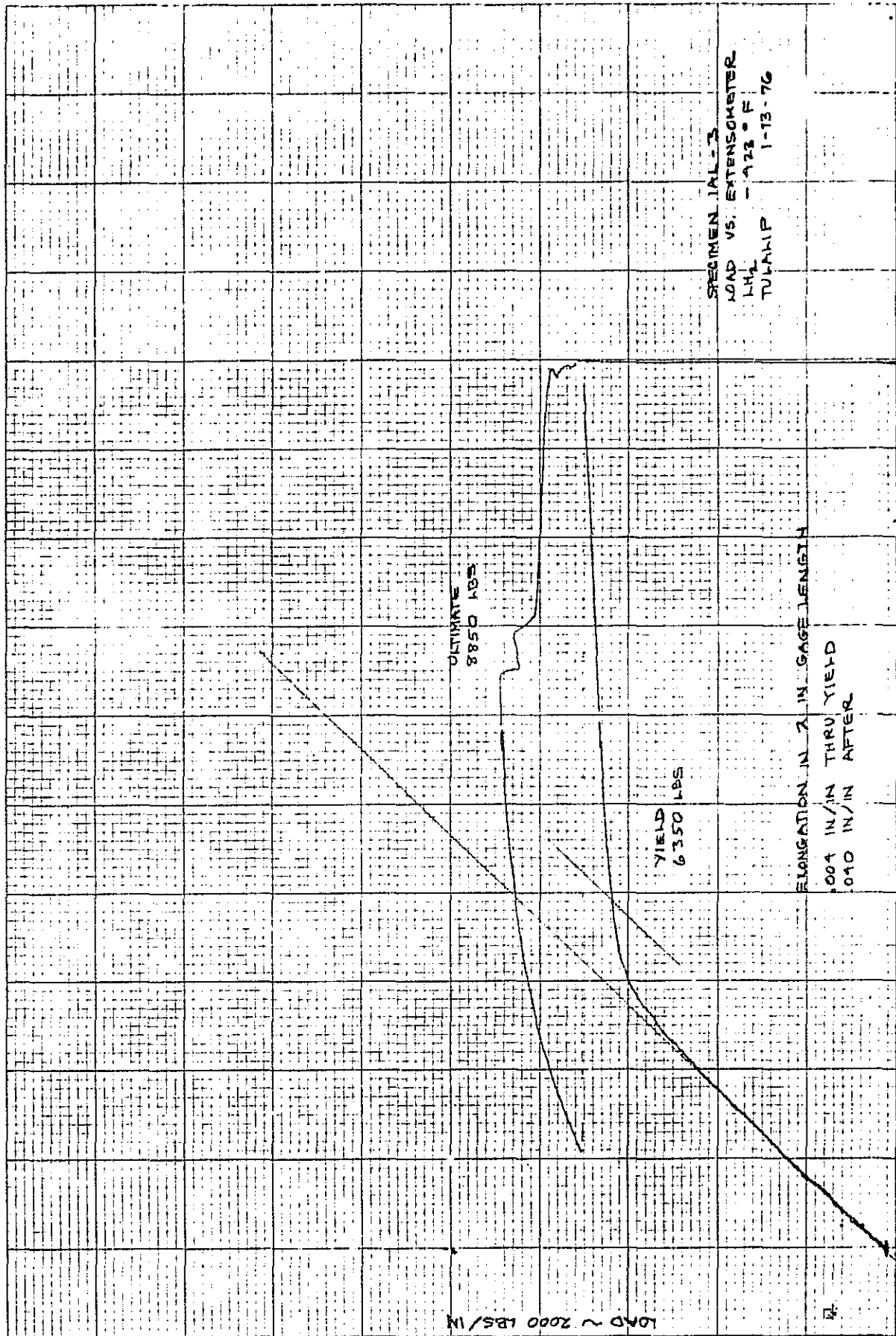


IAL-3
1-13-76

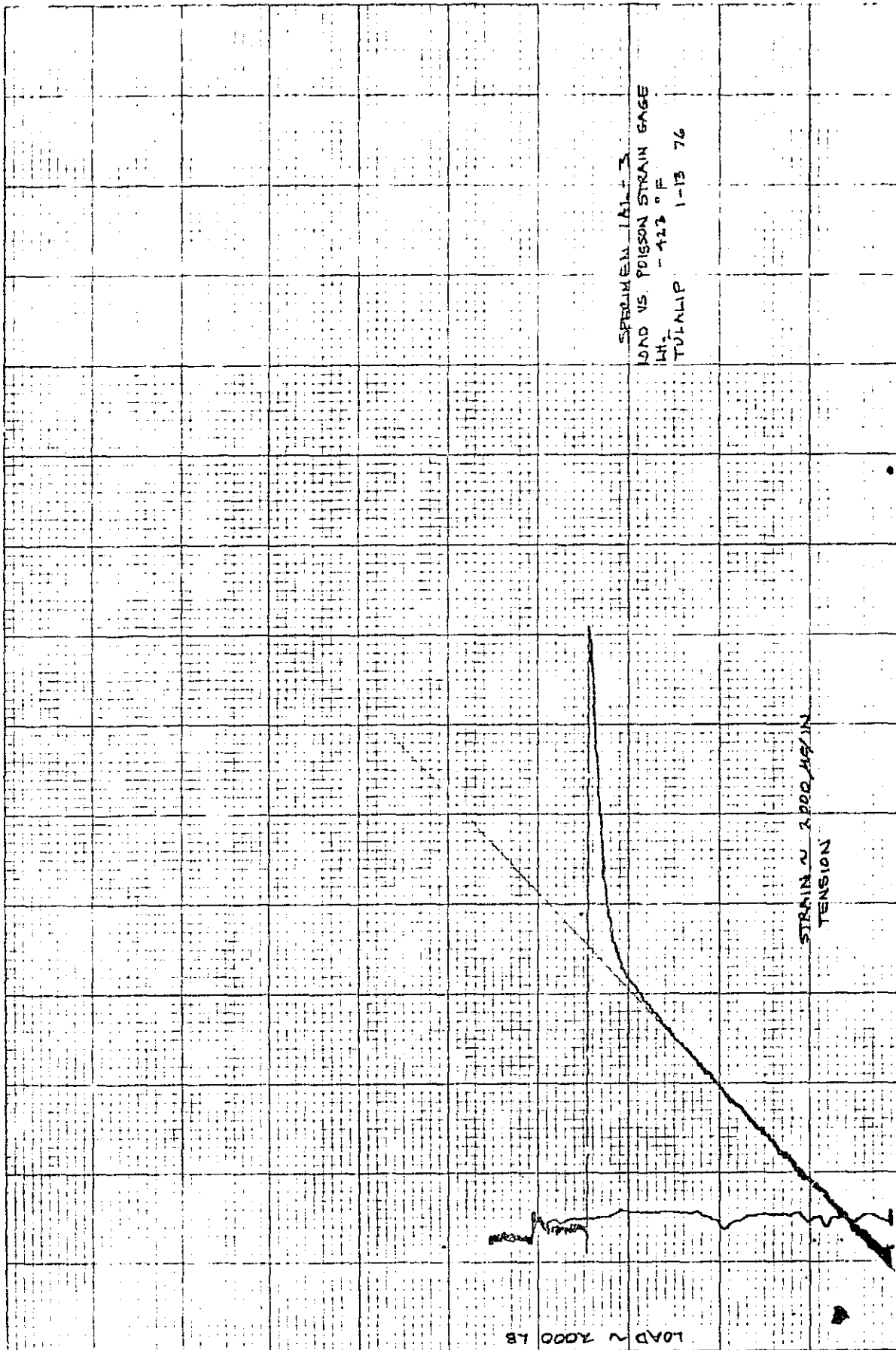
2000 LBS/IN

157

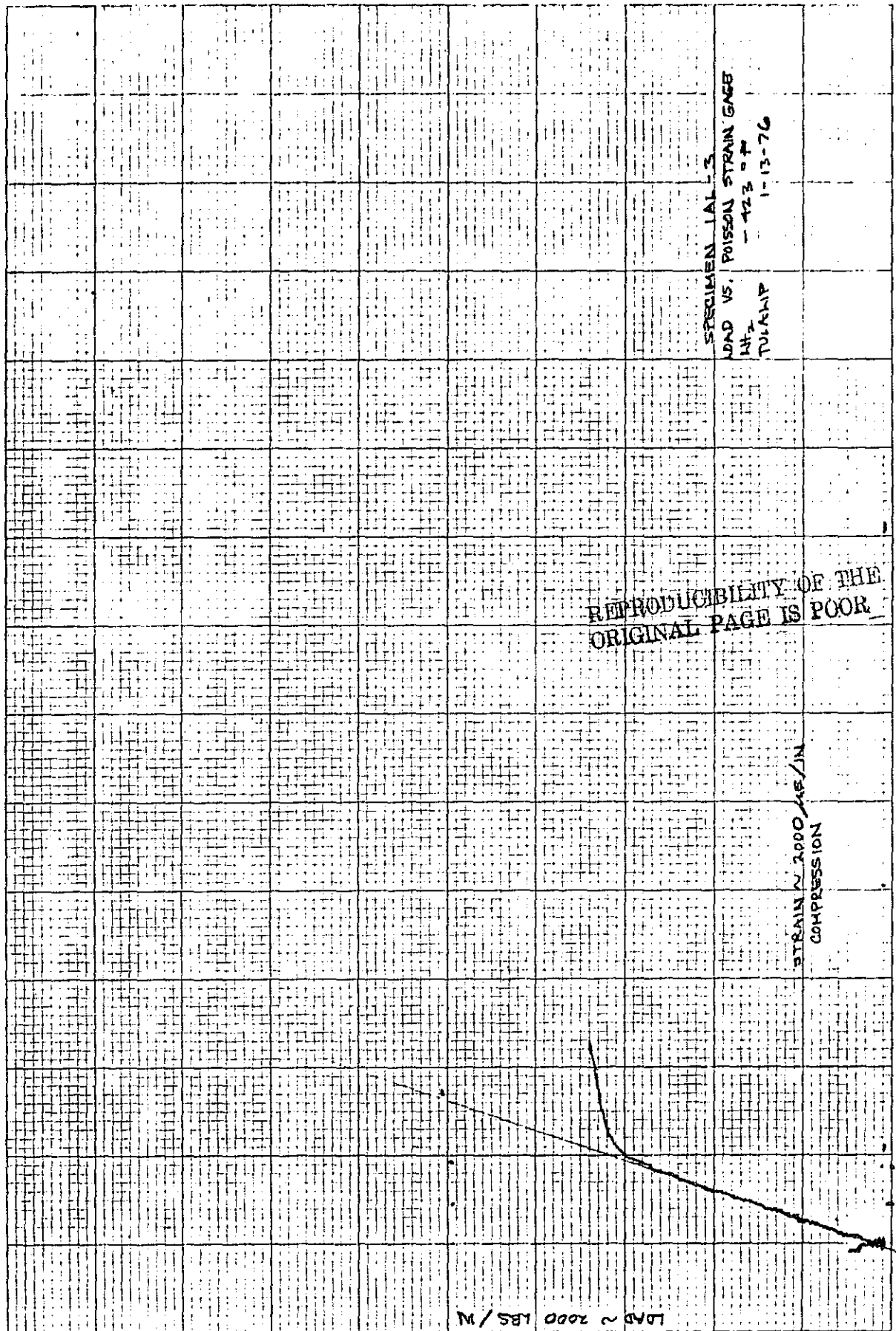
K-E 10 X 10 X 10 THE INCH 47 0700
MATERIAL & TESTER CO



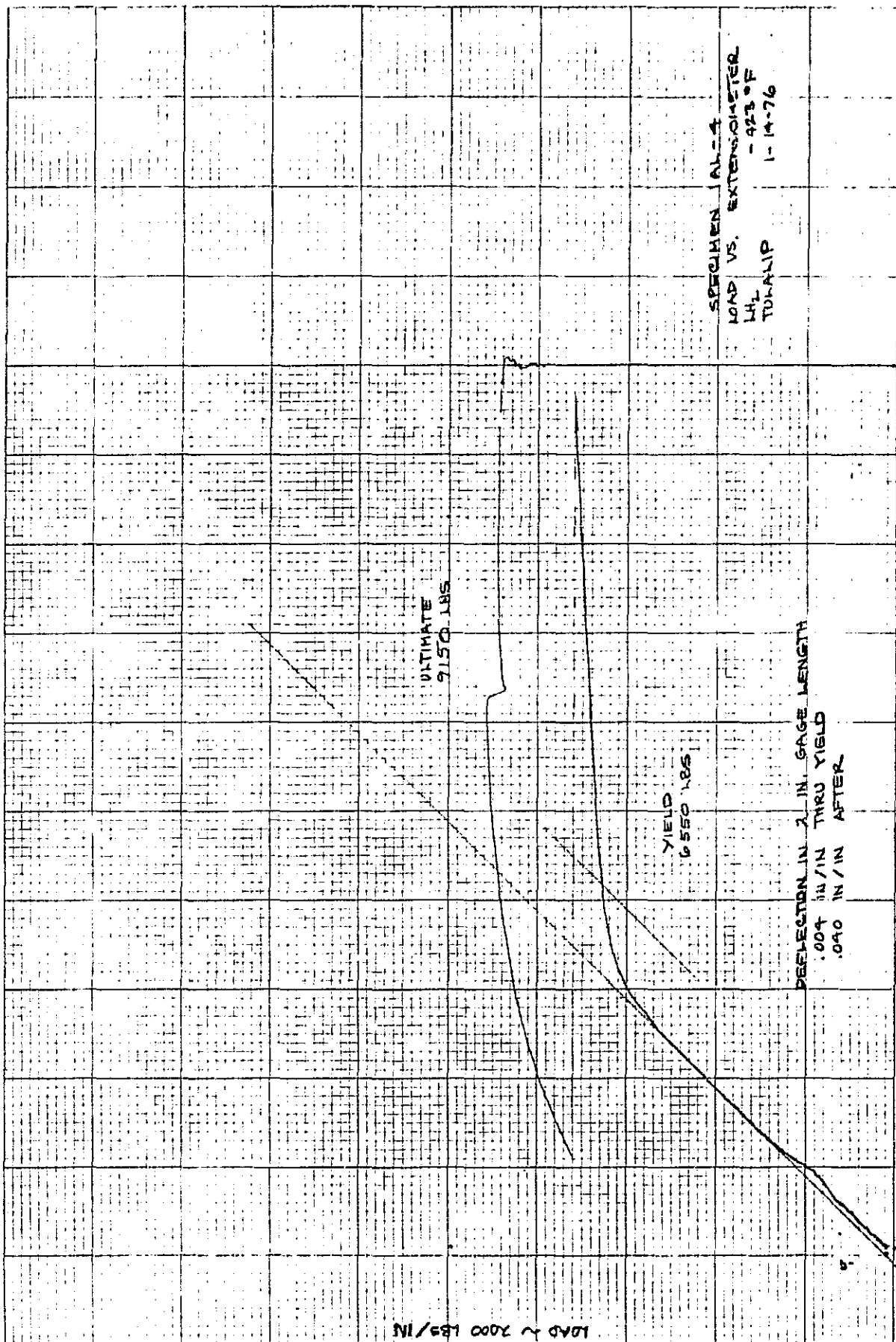
REPRODUCIBILITY OF THE
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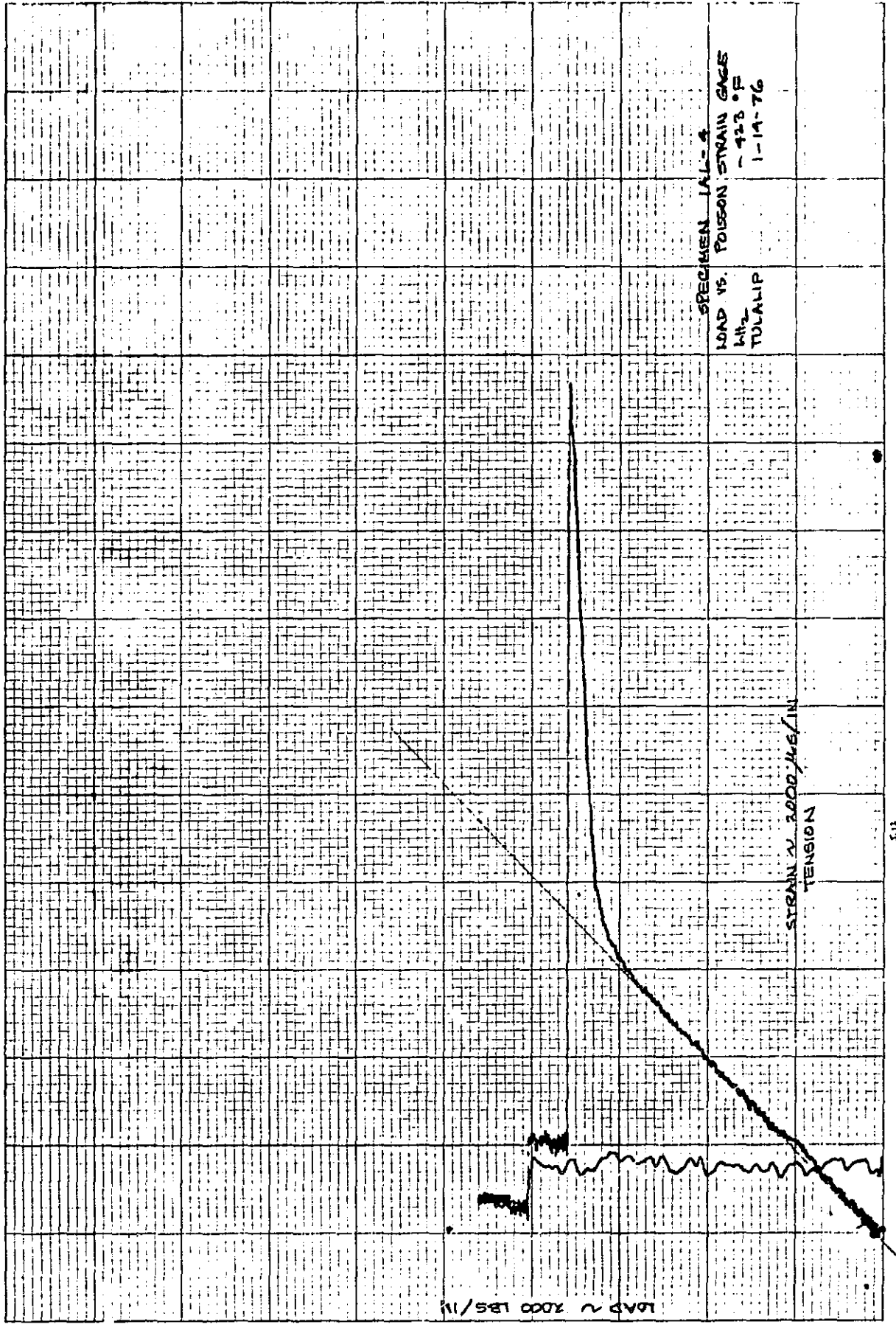
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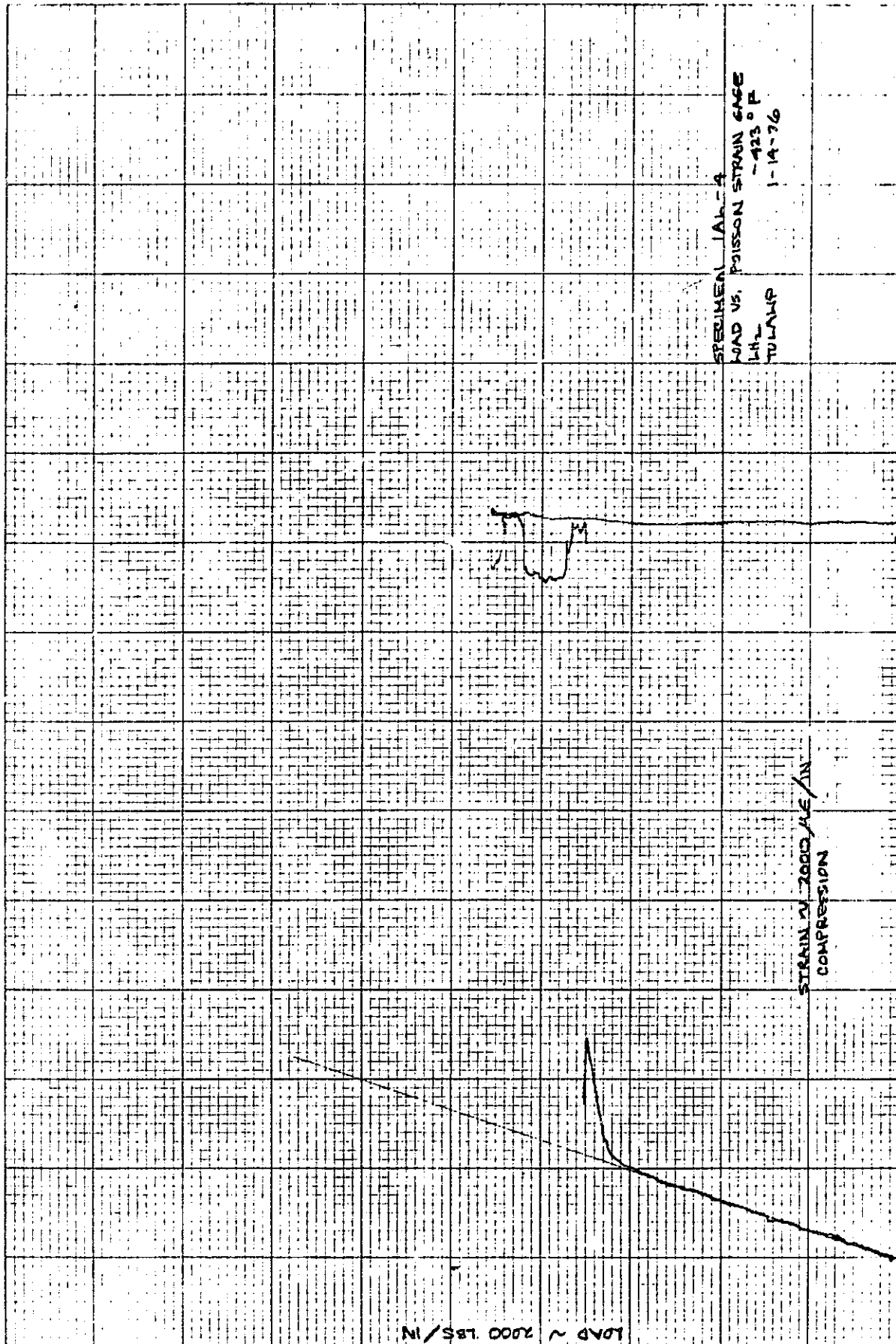


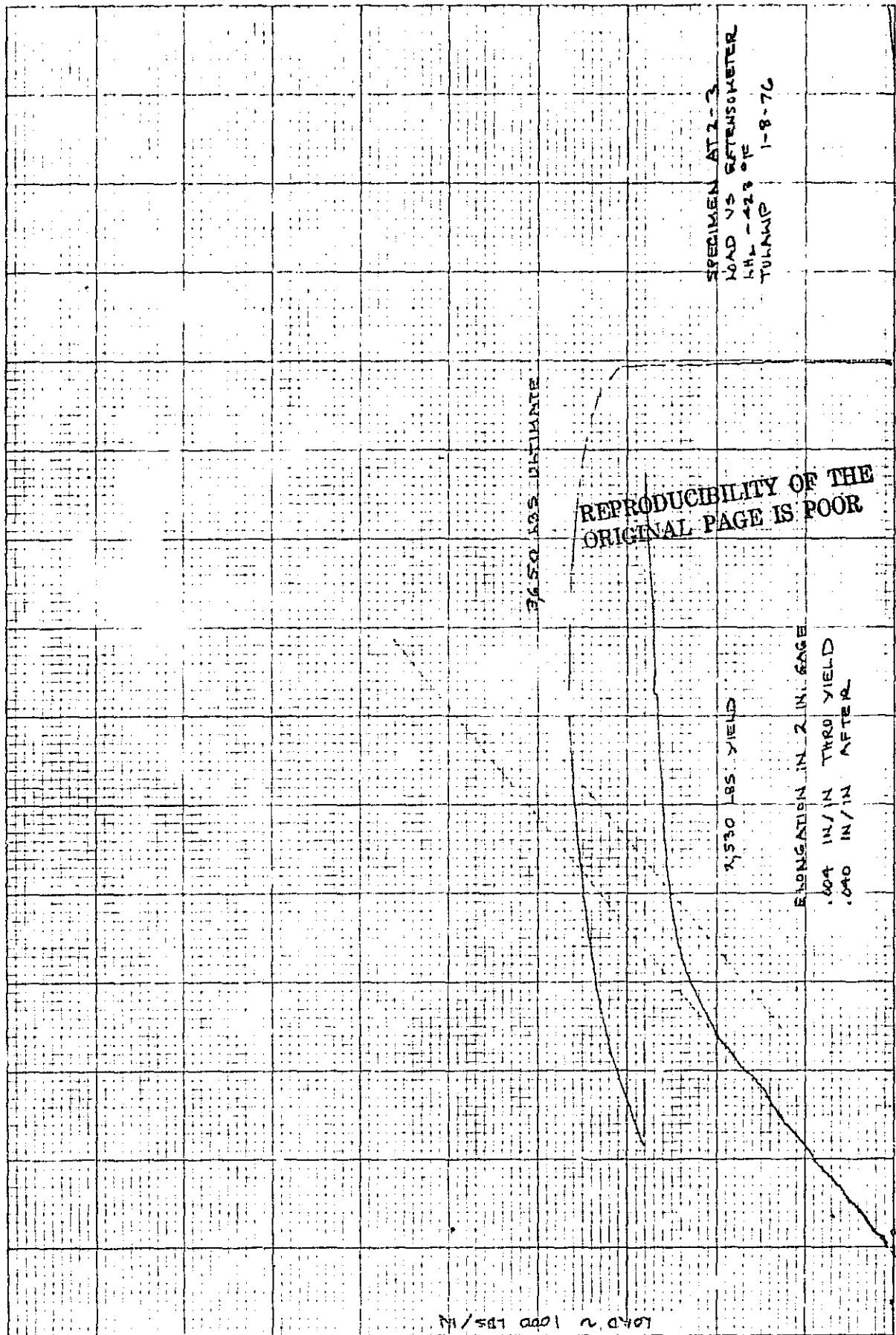
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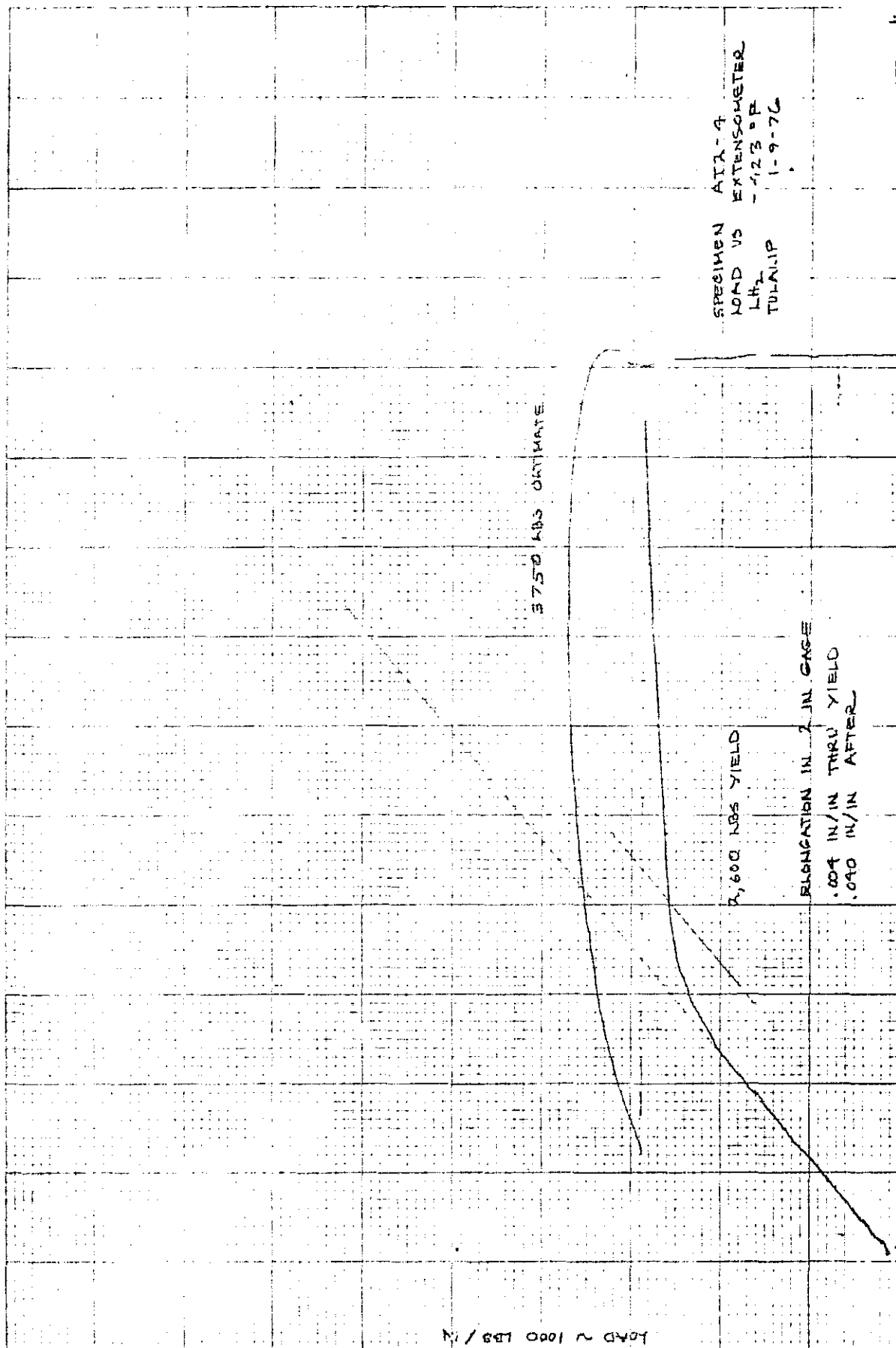


1-14-76

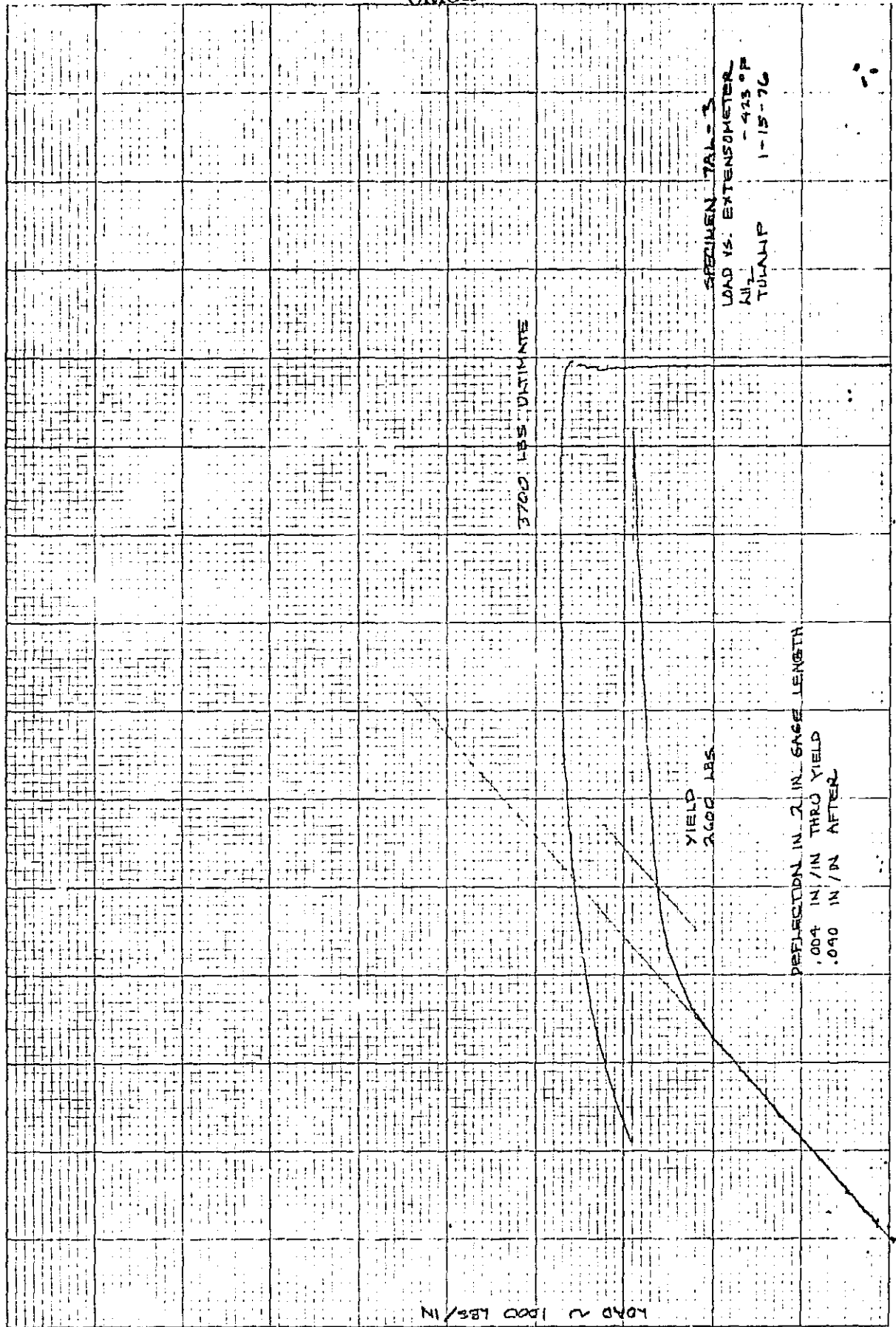






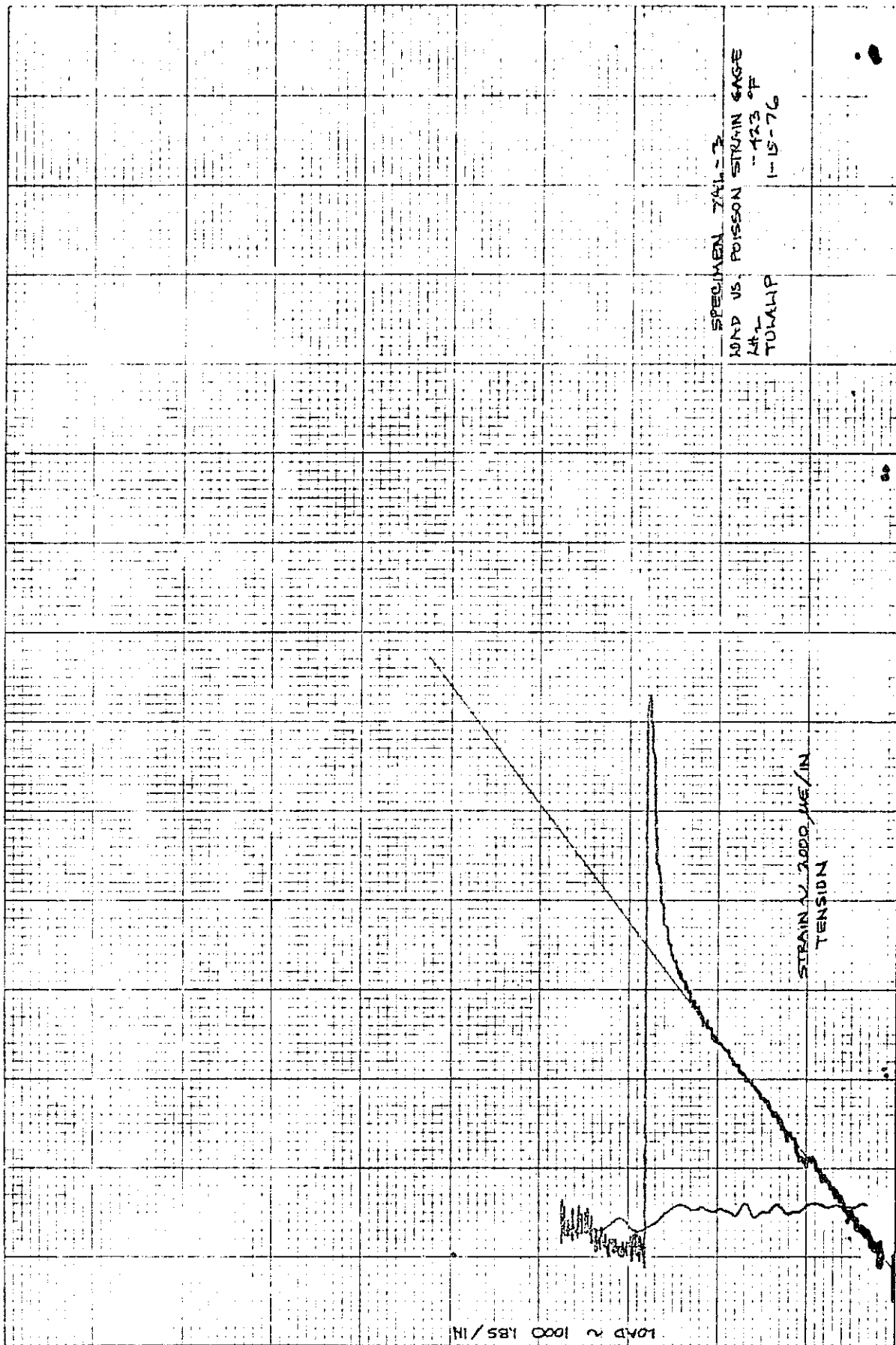


REPRODUCIBILITY OF THE
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11-3
15-76

7AL-3
1-14-76

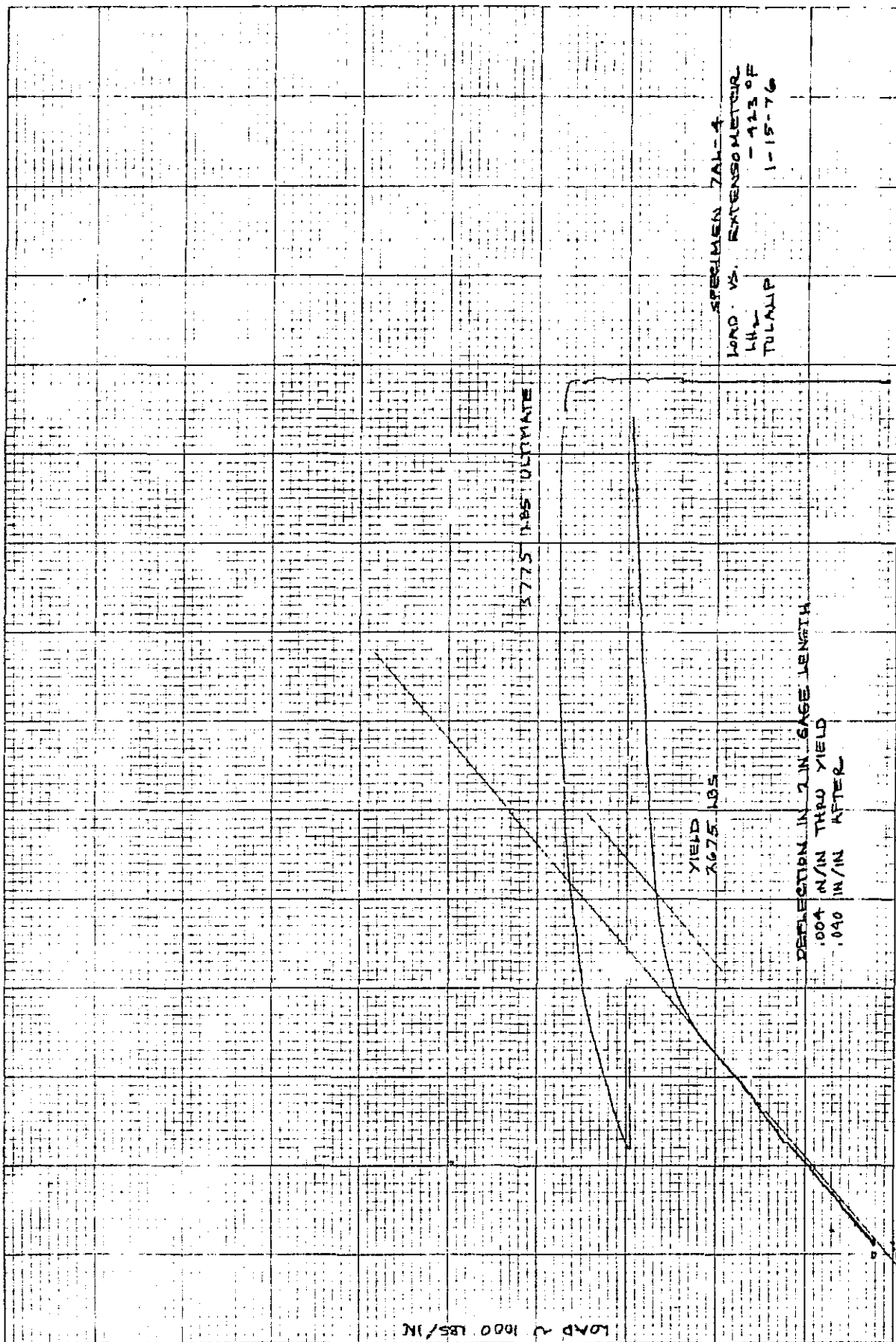


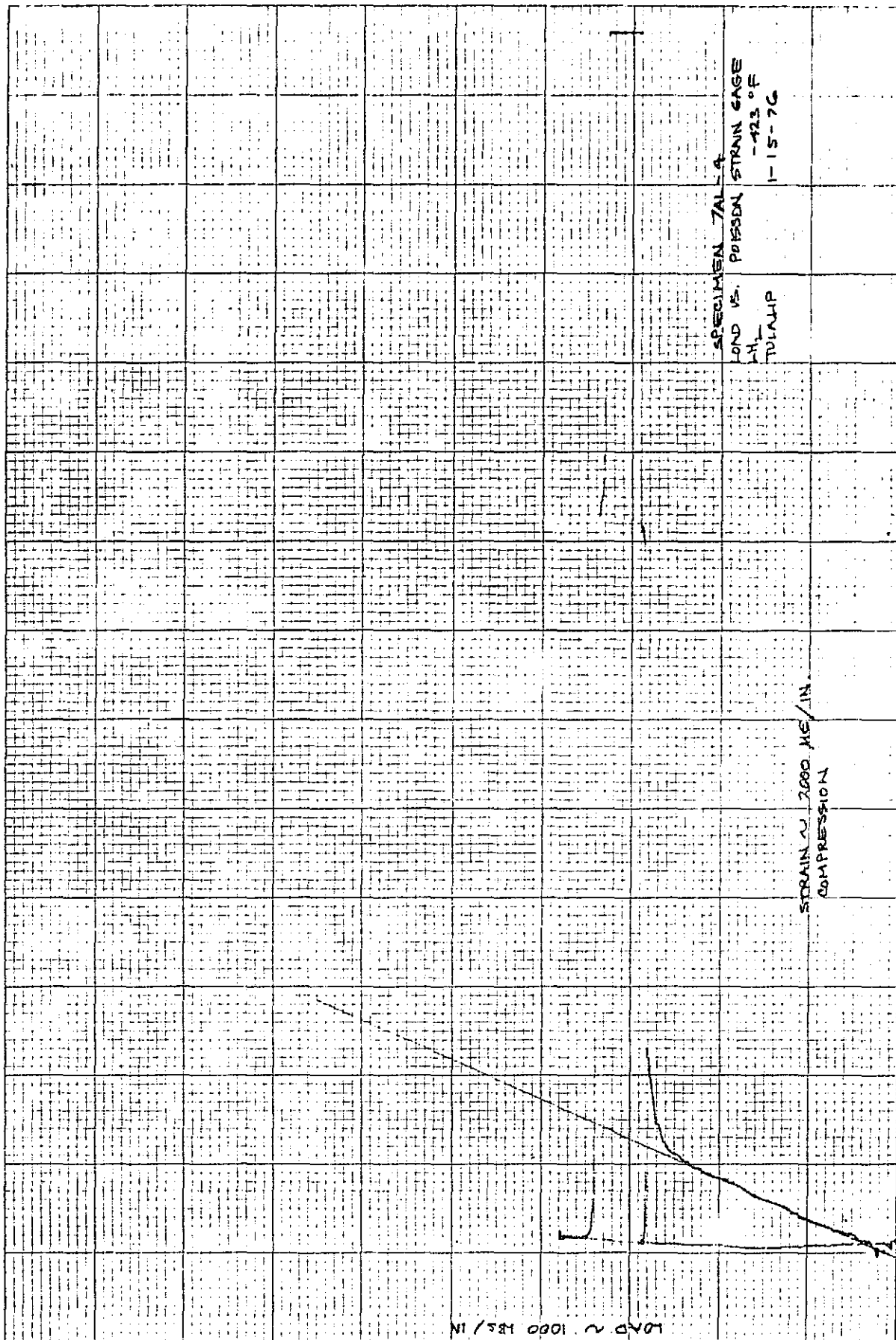
REPRODUCIBILITY OF THE
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SPECIMEN 7AL-3
LOAD VS. POISSON STRAIN GAGE
- 403 OF
1-15-76
TULALIP

STRAIN 2000 $\mu\epsilon$ /IN
COMPRESSION

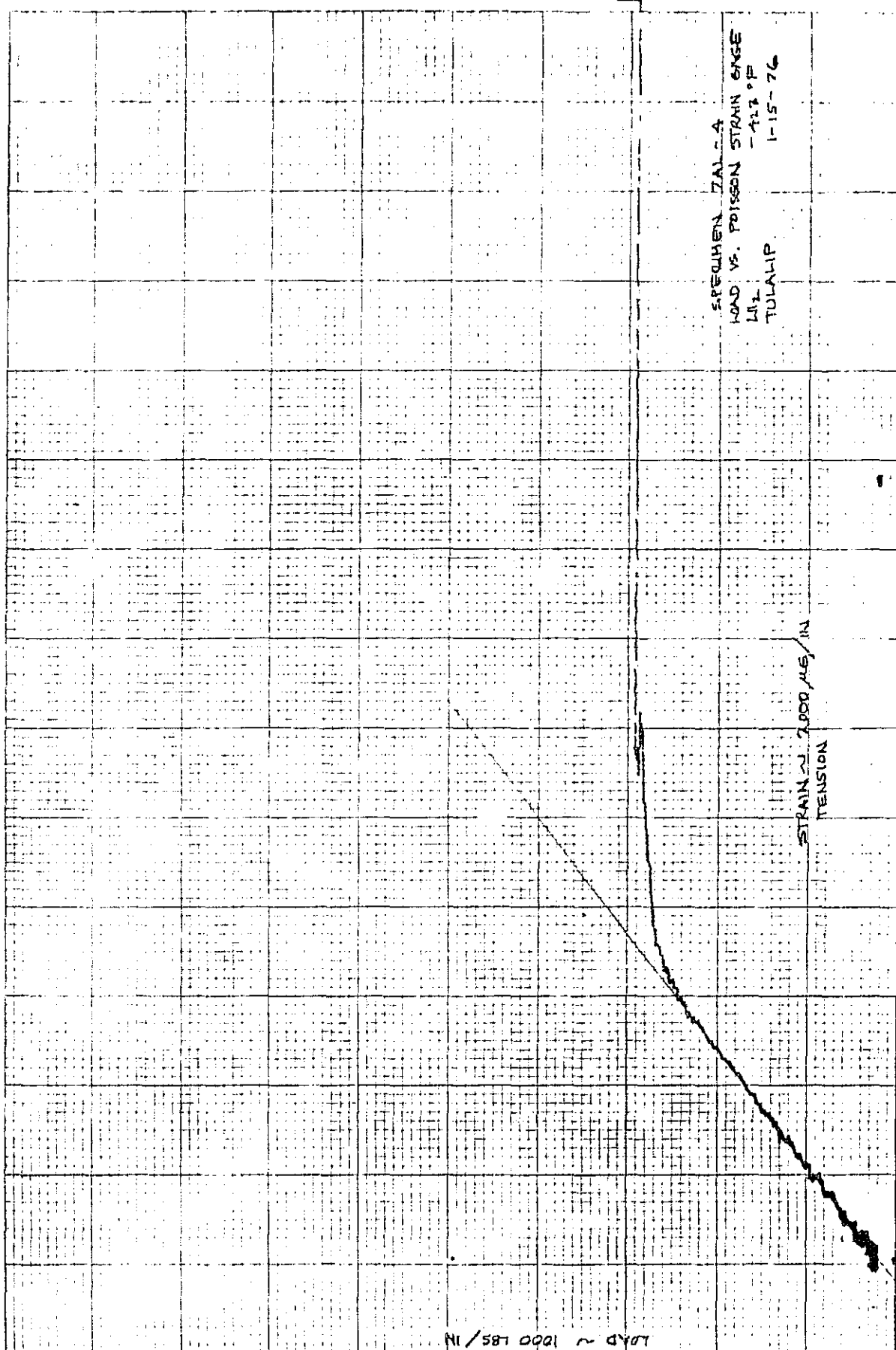
LOAD 1000 LBS





LOAD ~ 1000 LB/IN

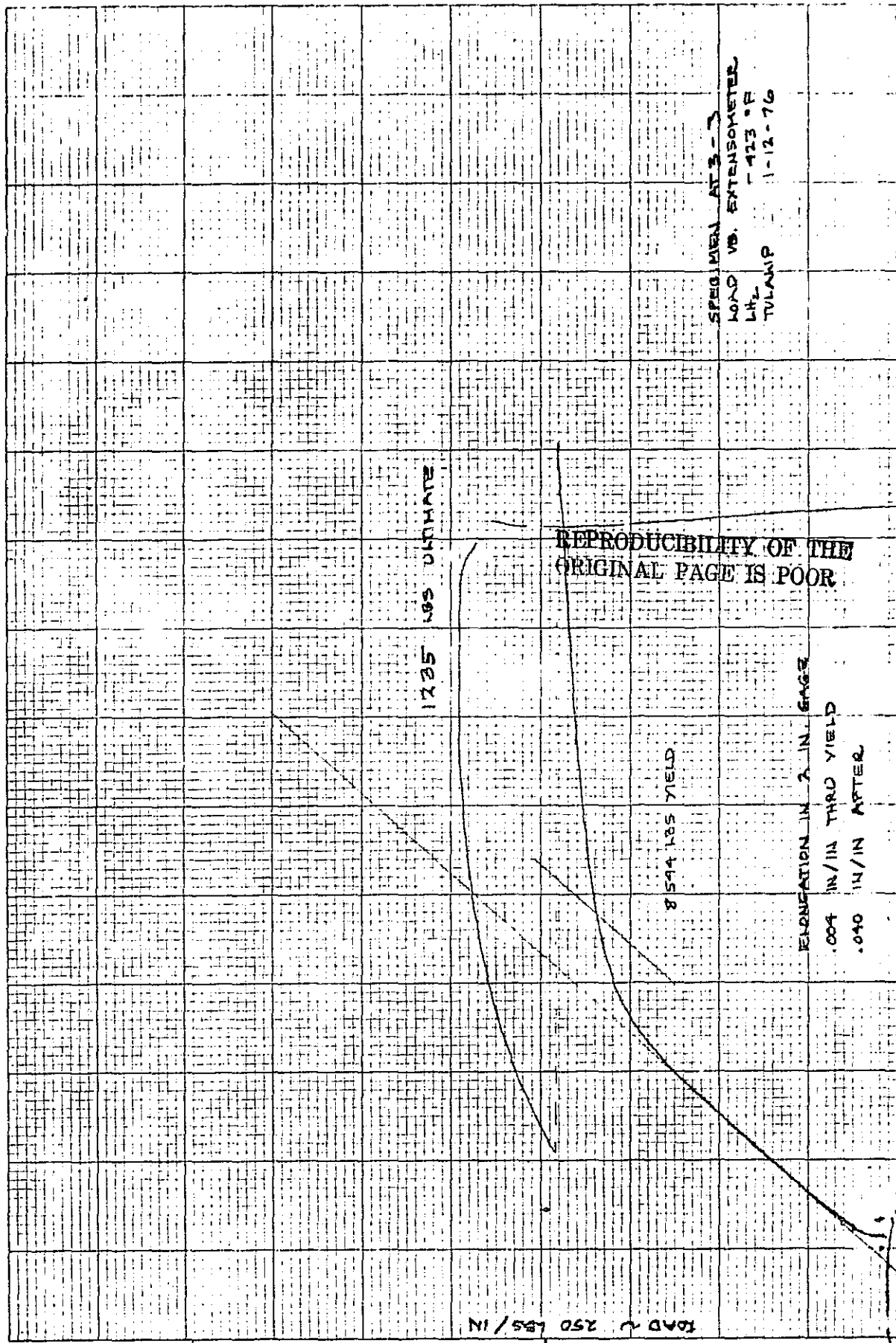
7-1-76
1-15-76



LOAD ~ 1/185 IN

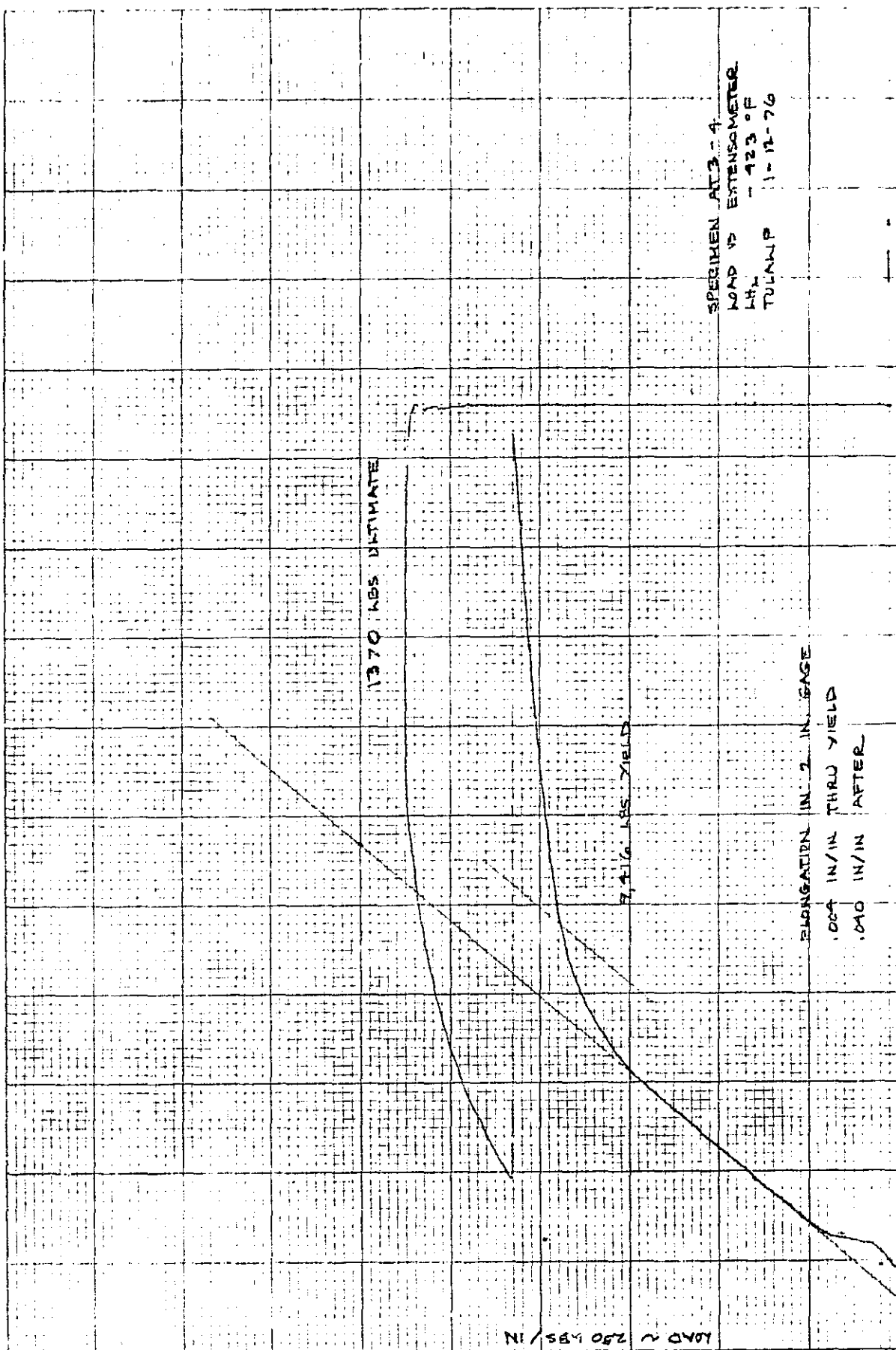
SPECIMEN 7A1-4
LOAD VS. POISSON STRAIN GRAPH
L11
TULALIP
1-15-76

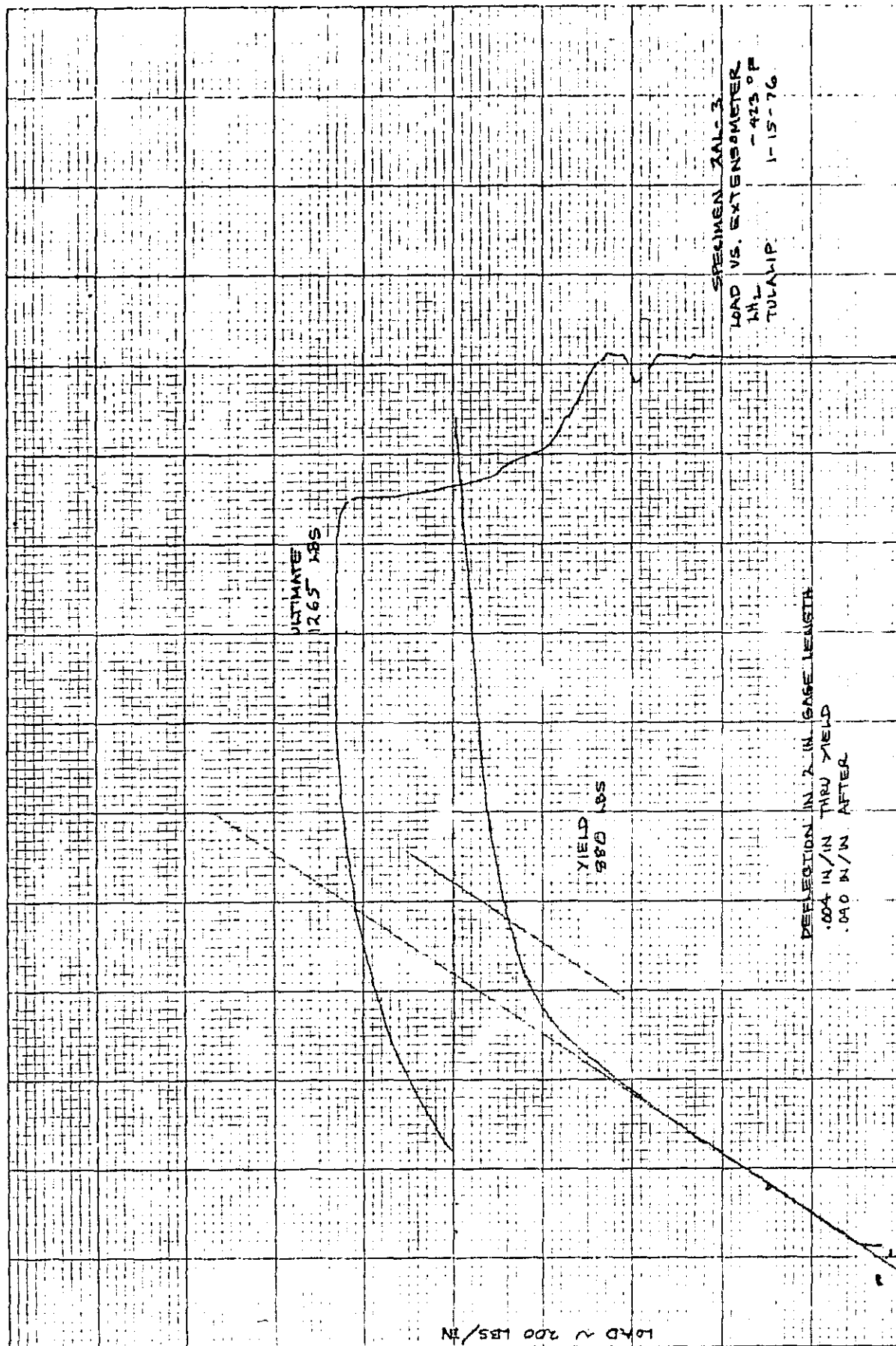
STRAIN ~ 1/1000 IN
TENSION



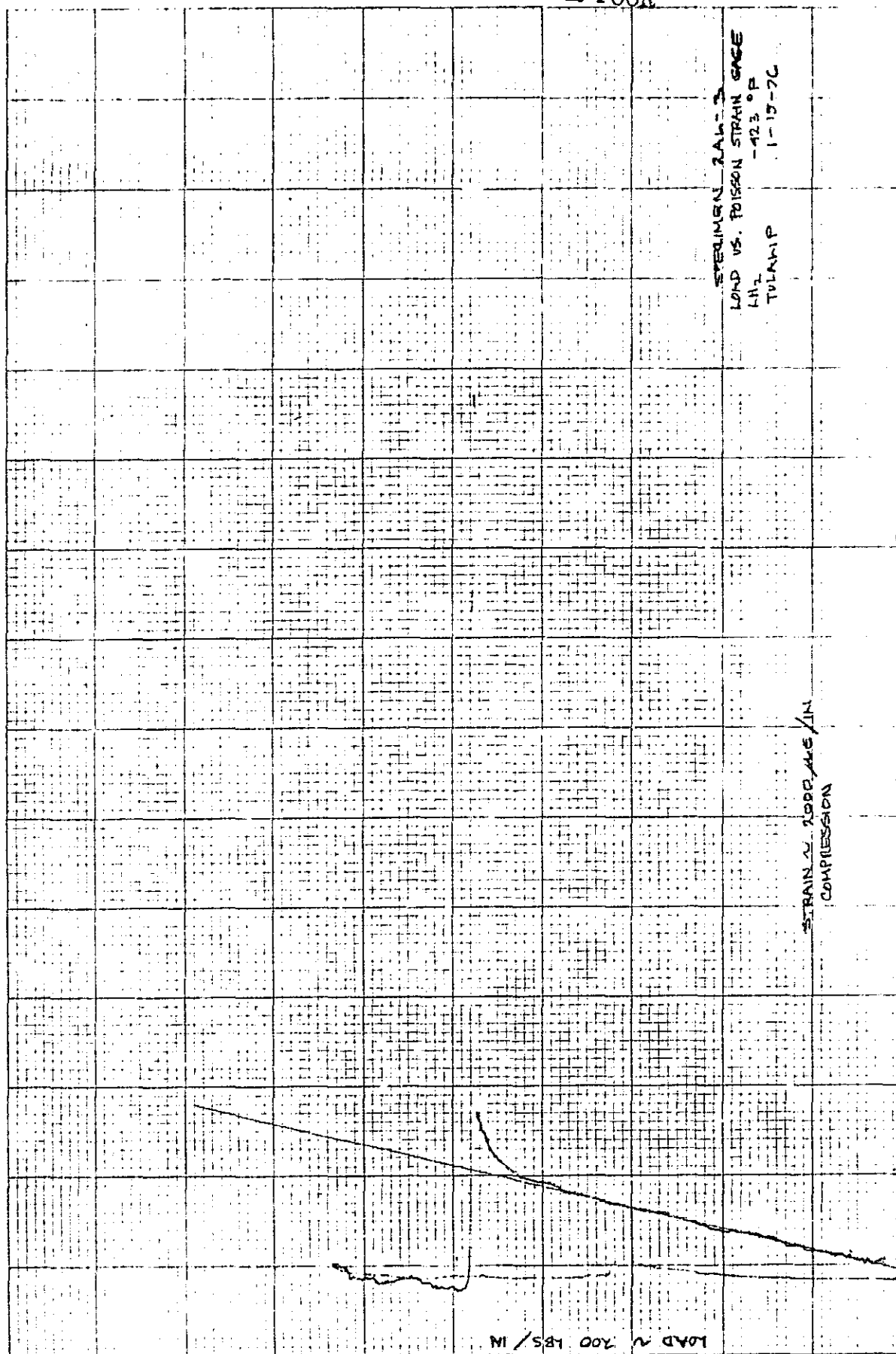
2-5
b-41

K-E 10.2 IN TO THE INCH 47 0703
RECEIVED & TESTED BY
10-10-76

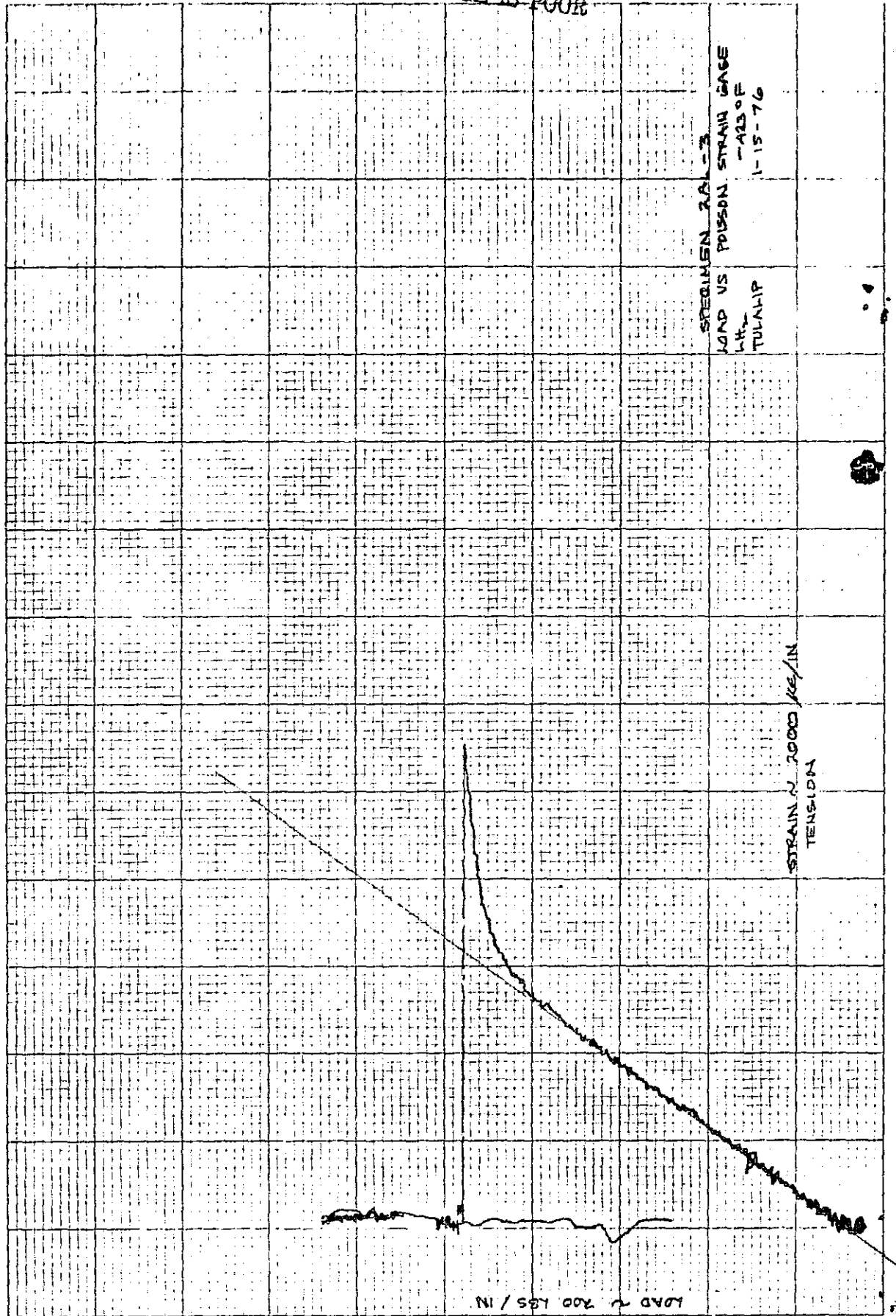




REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



SPECIMEN 2A-3
LOAD VS POISSON STRAIN GAGE
-A23 OF
LH-
TULAHIP
1-15-76

A-3
1-76

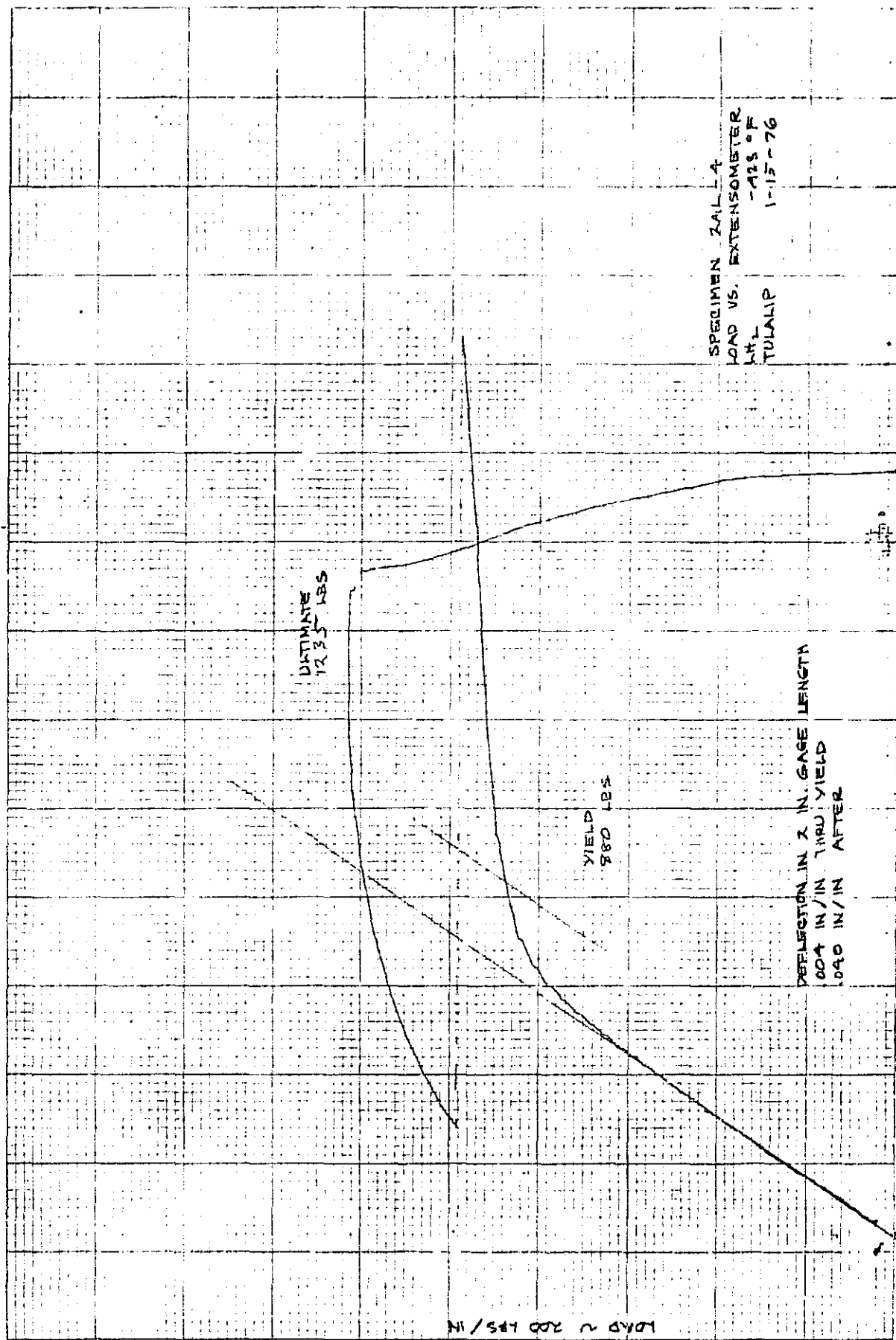
ZAL-4
1-15-76

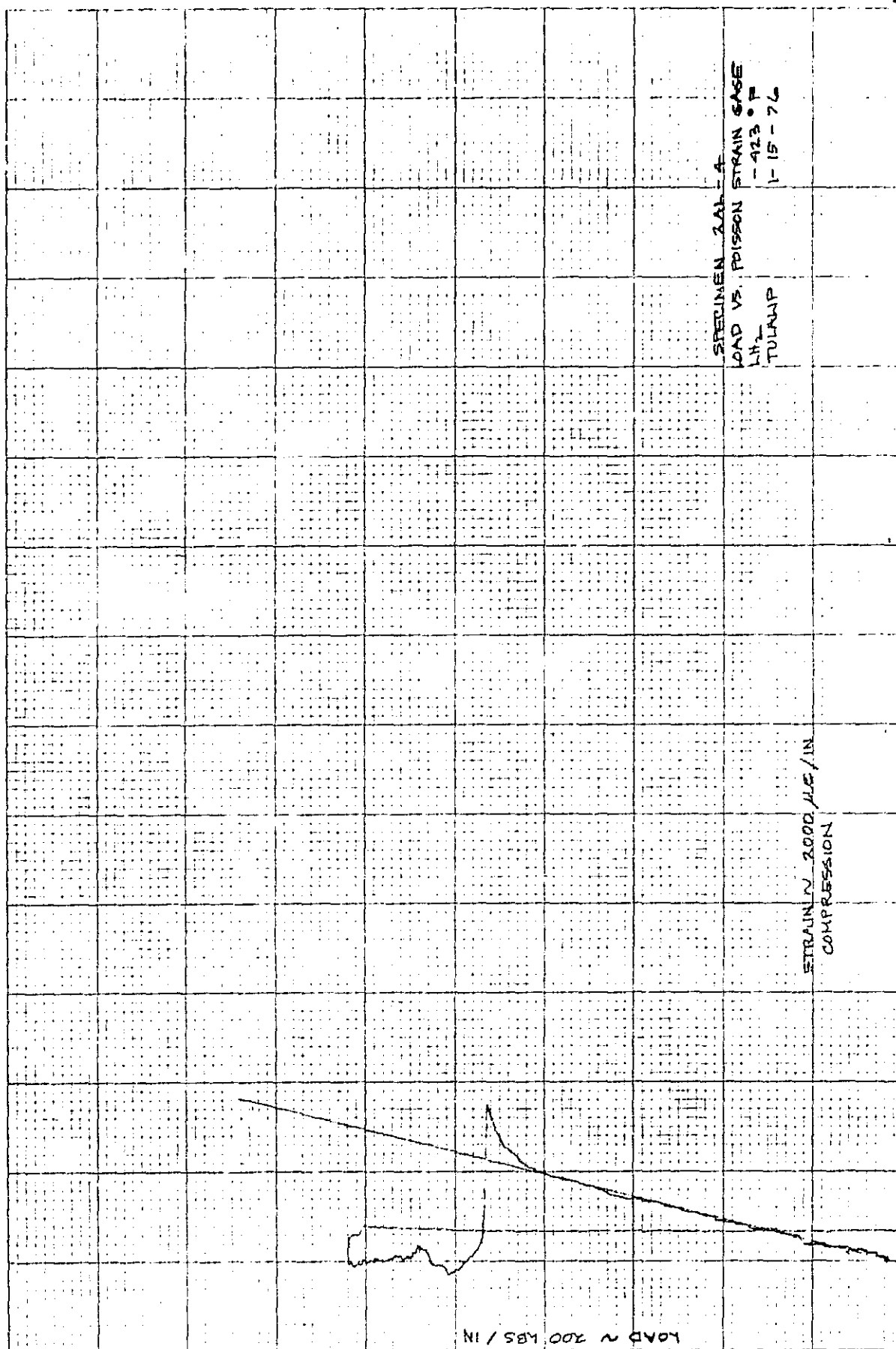
2000 PSI

176

K-3 10 X 10 TO THE INCH 47 0703

SUPPLY & POWER CO.

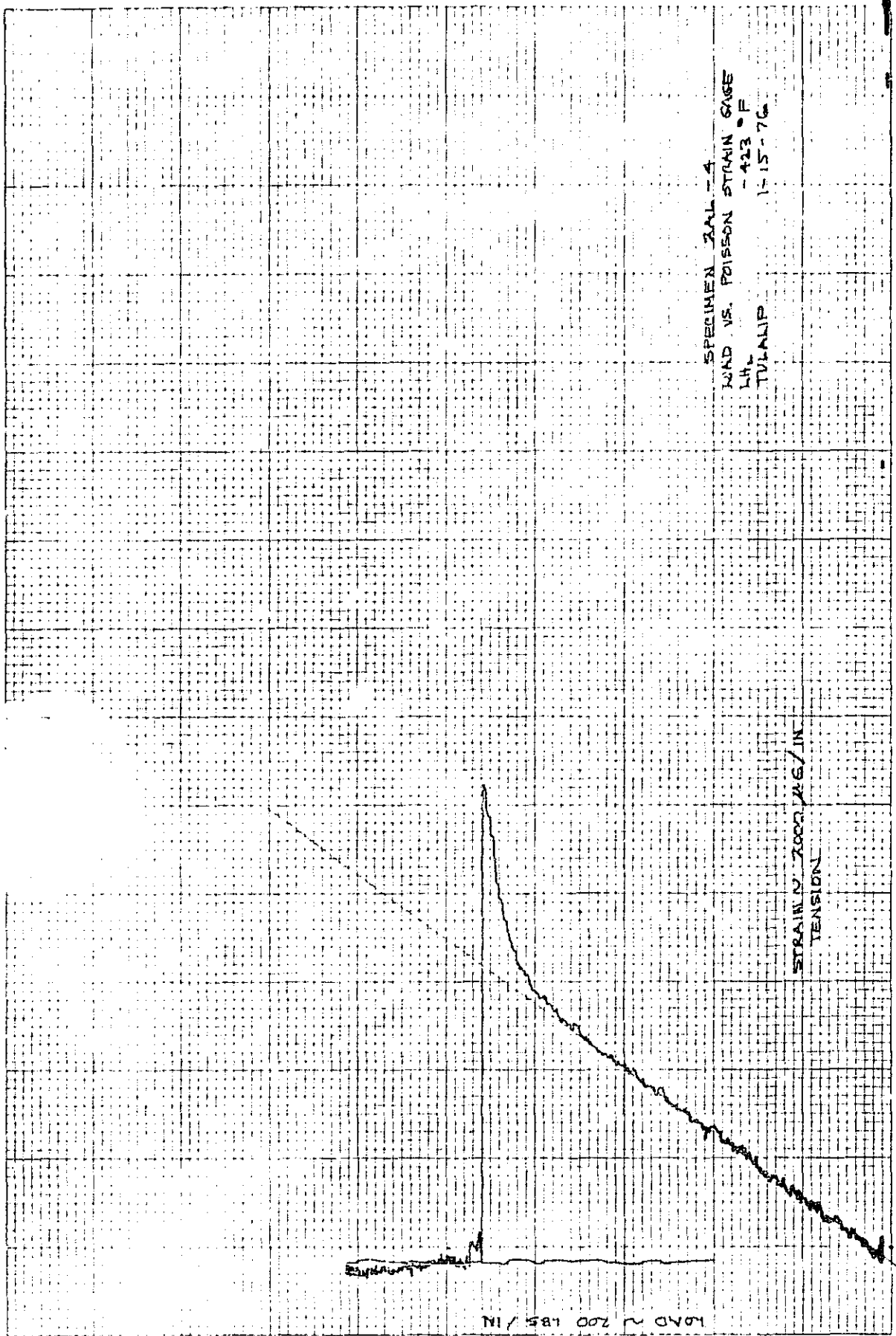




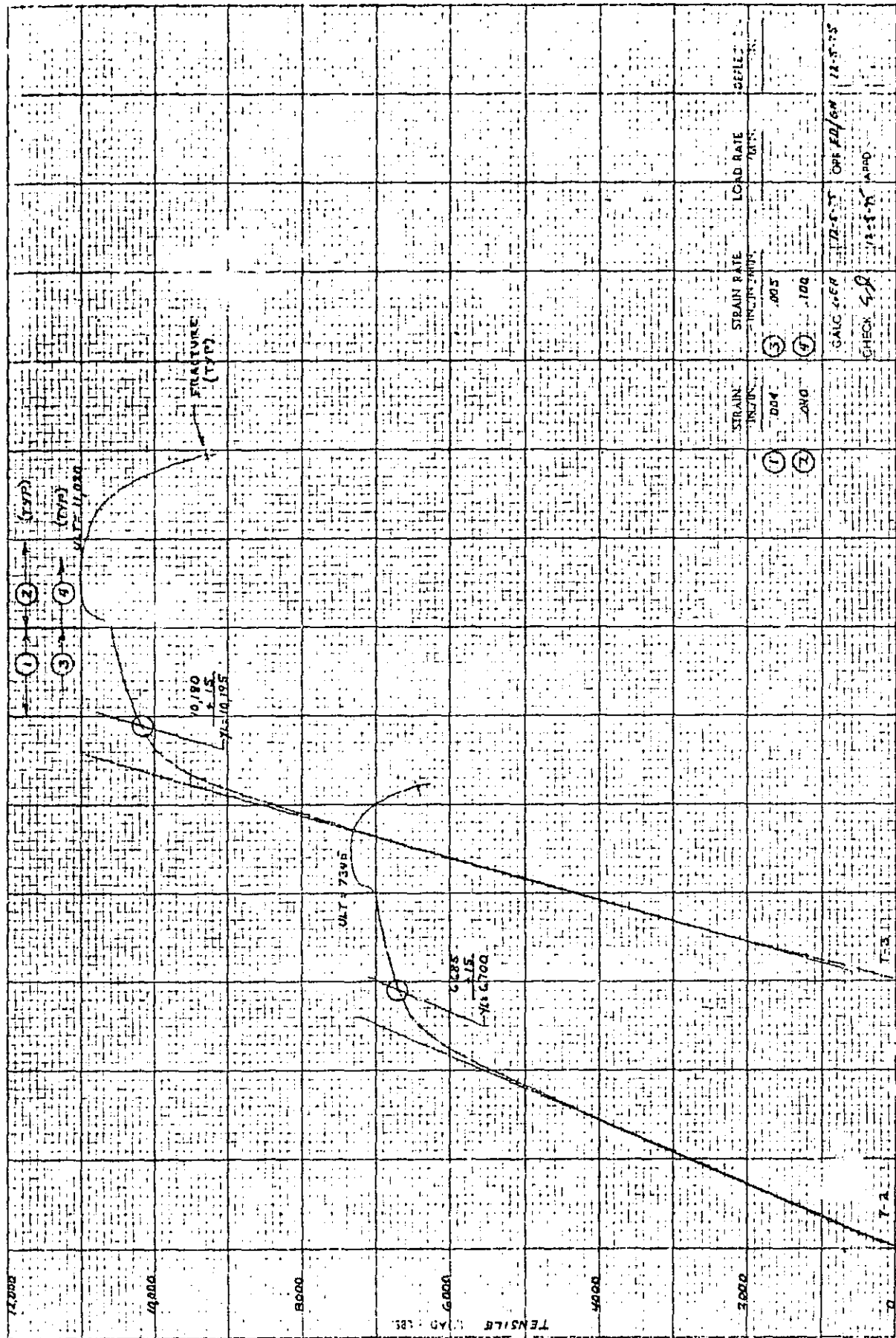
SAAL-4
1-15-76

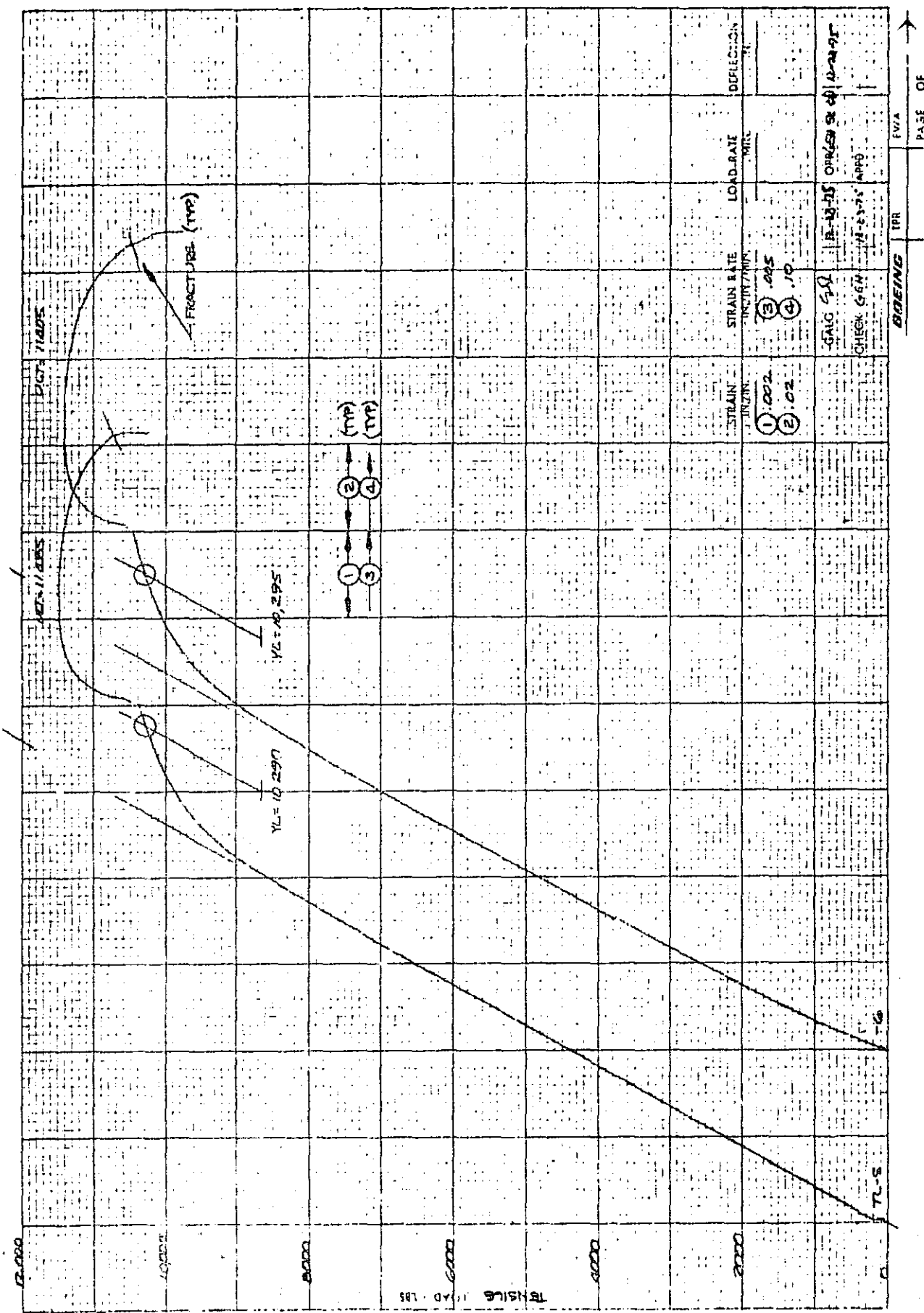
47 0703

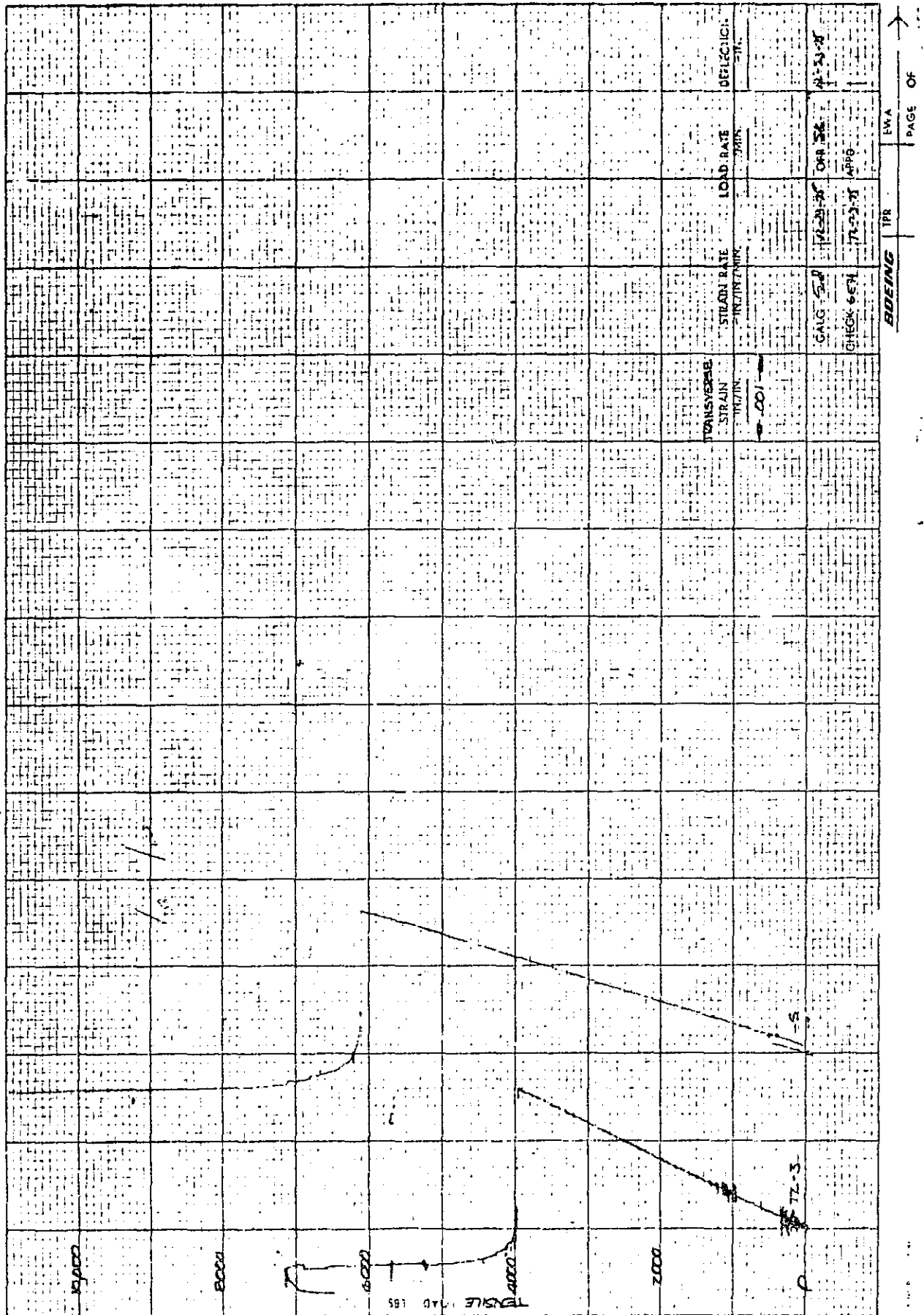
K-E 11.2 TO 12.5 INCHES
ALUMINUM STRAIN GAGE

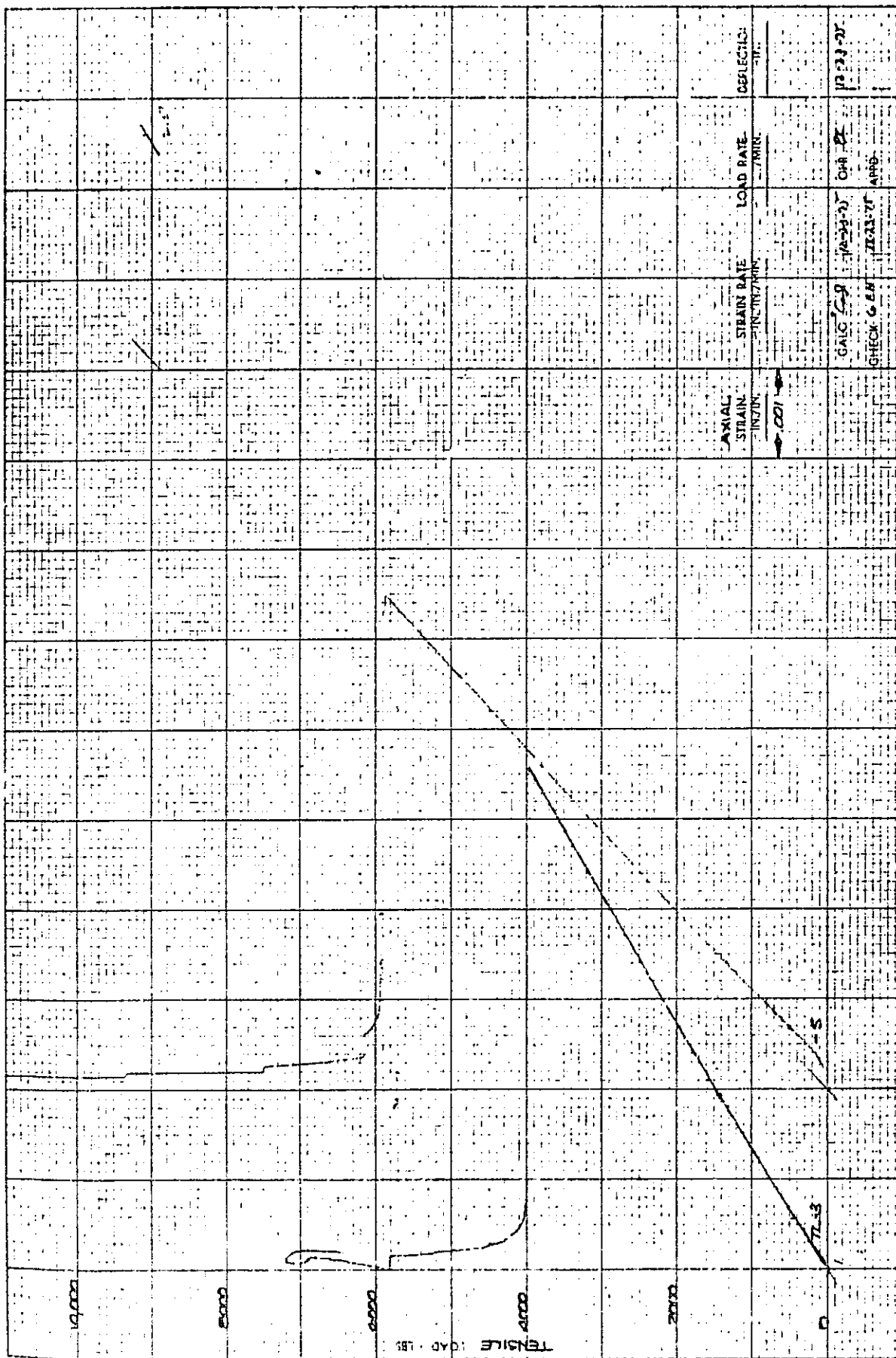


SPECIMEN 3AL-4
WIND VS. POISSON STRAIN GAGE
- 423 °F
TULALIP 1-15-76









BOEING IPR

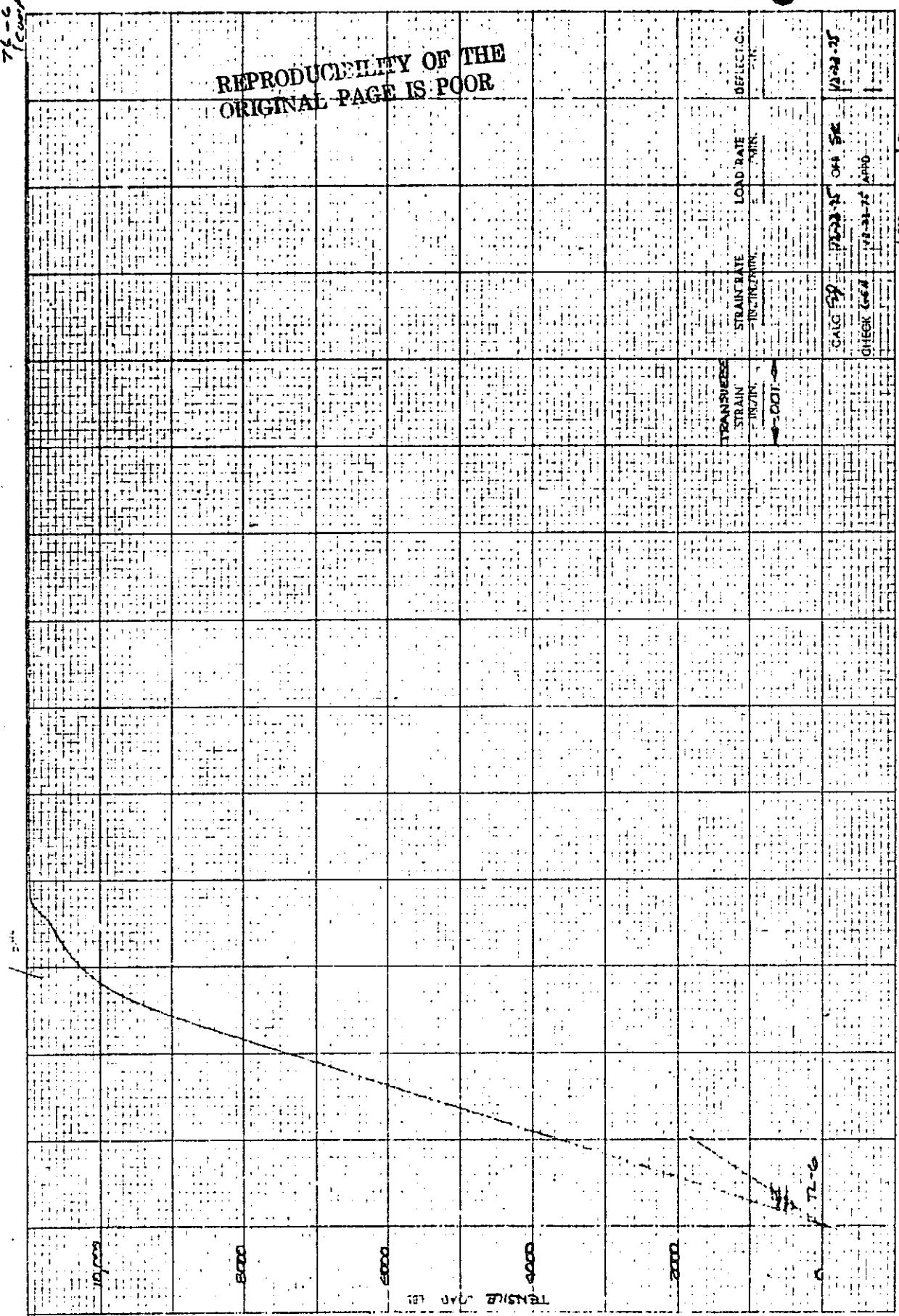
EVA

PAGE OF



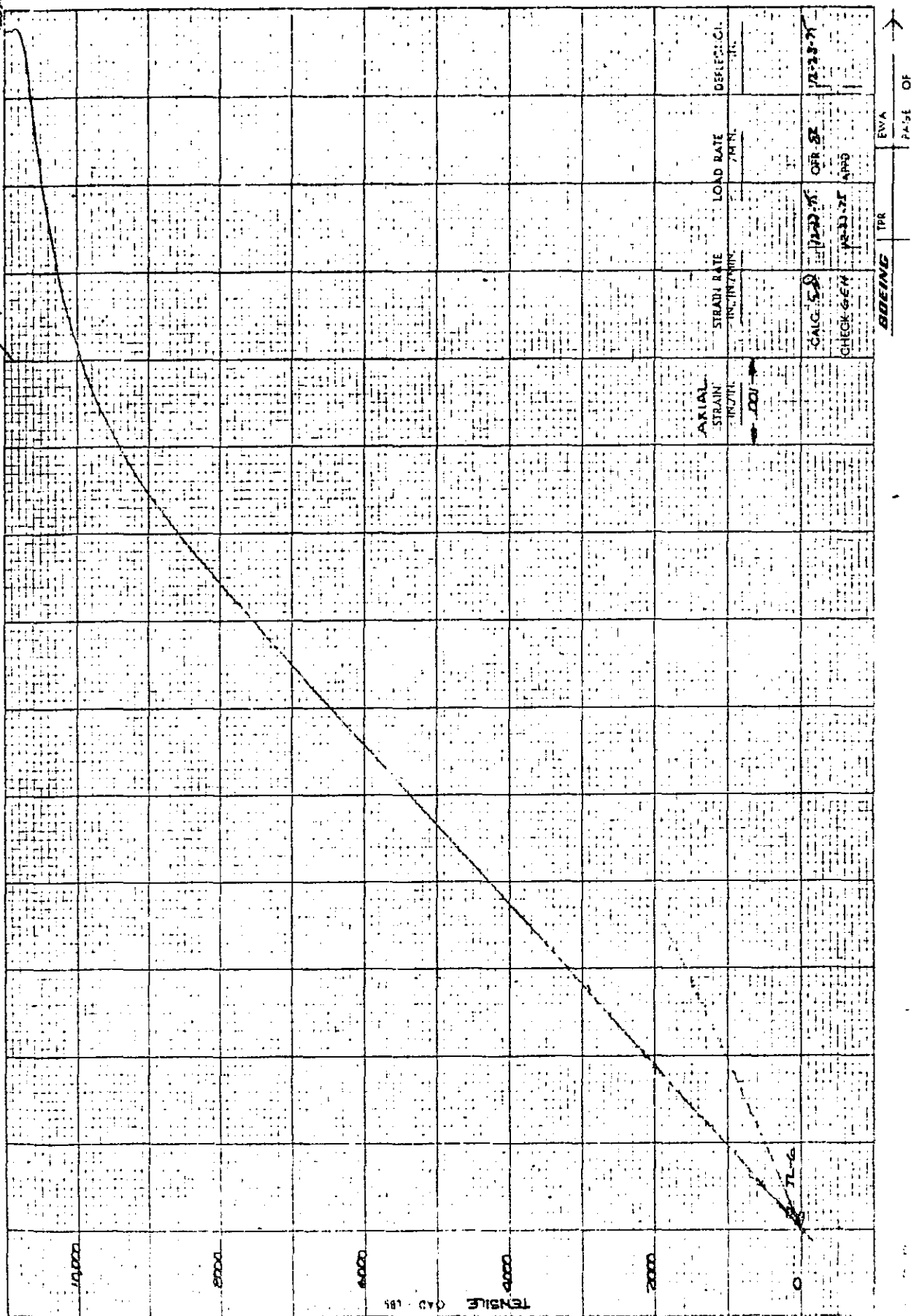
76-6
(Cover)

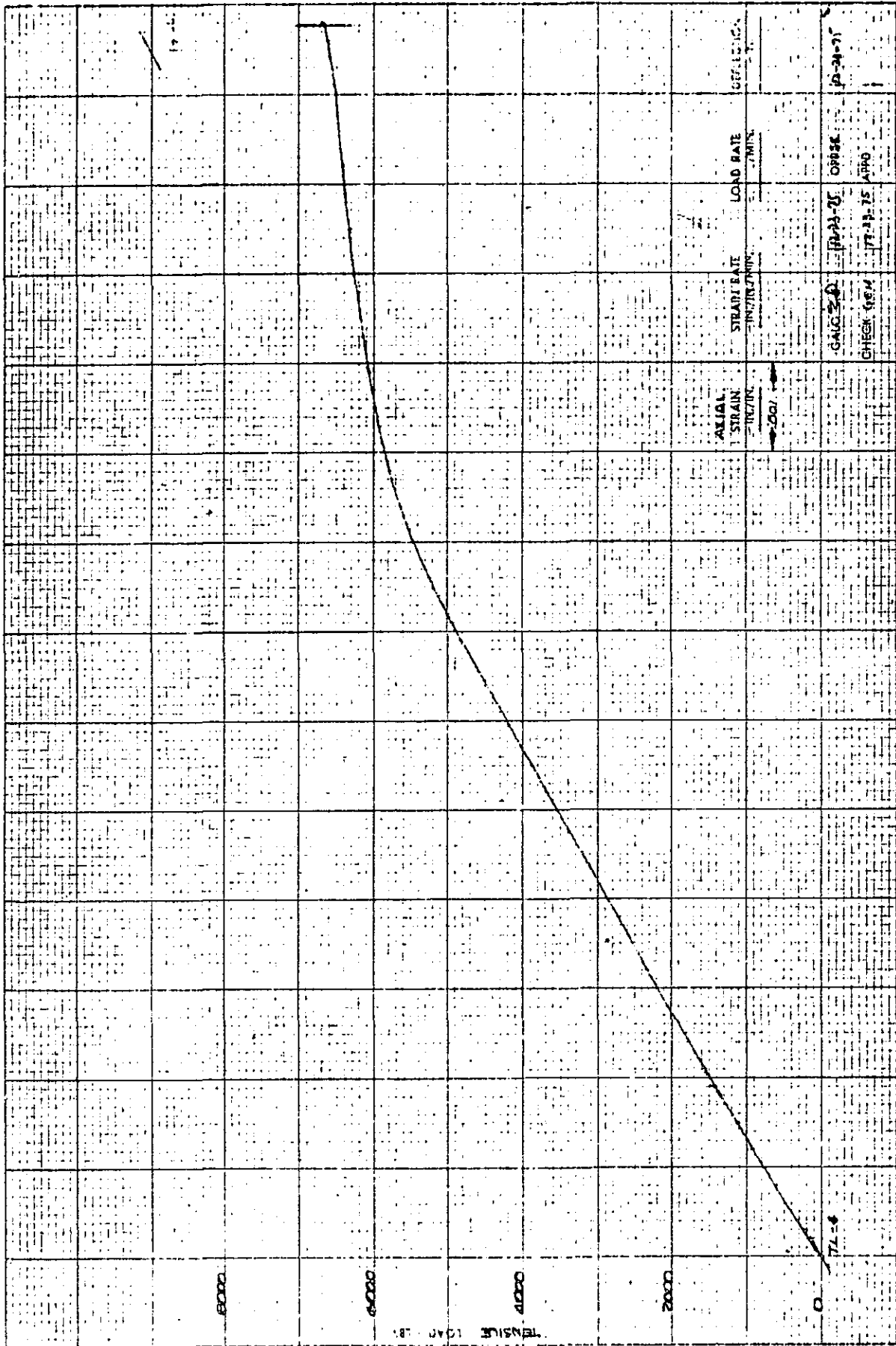
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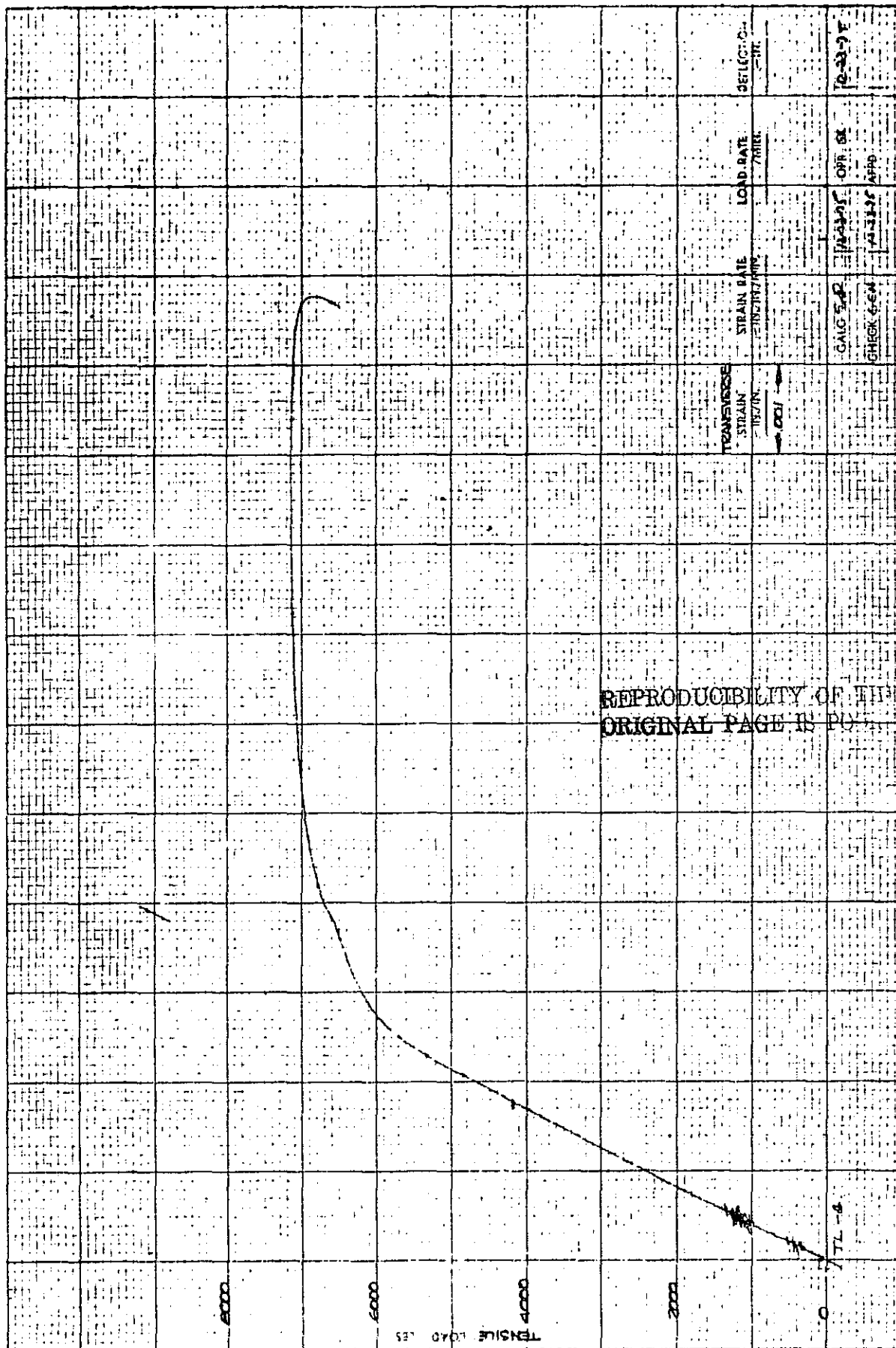


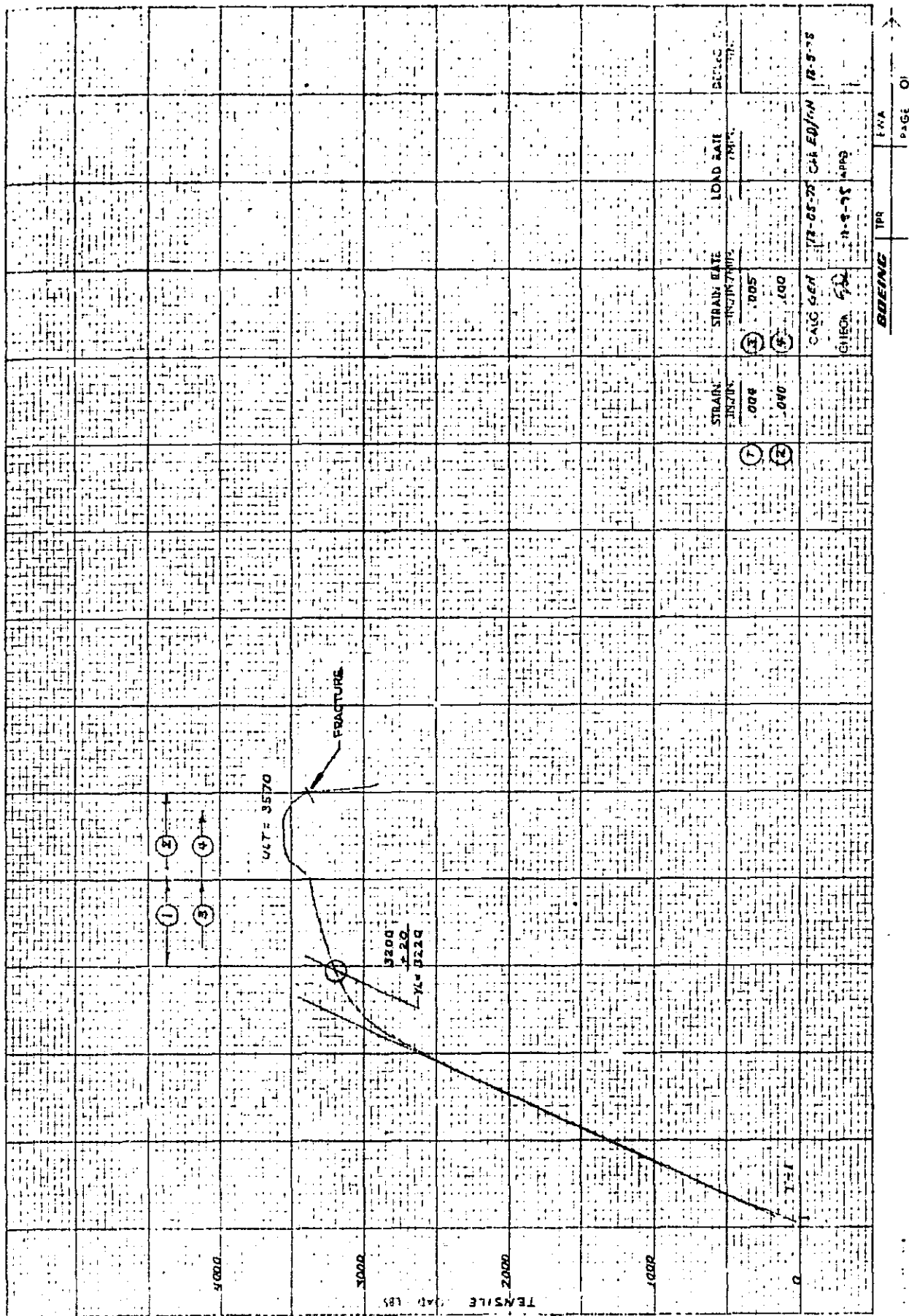
BOEING		TPR	EWA	PAGE	OF
GAGE	76-6-15	OFF	500	13-23-75	
CHECK	664	13-23-75	APPD		

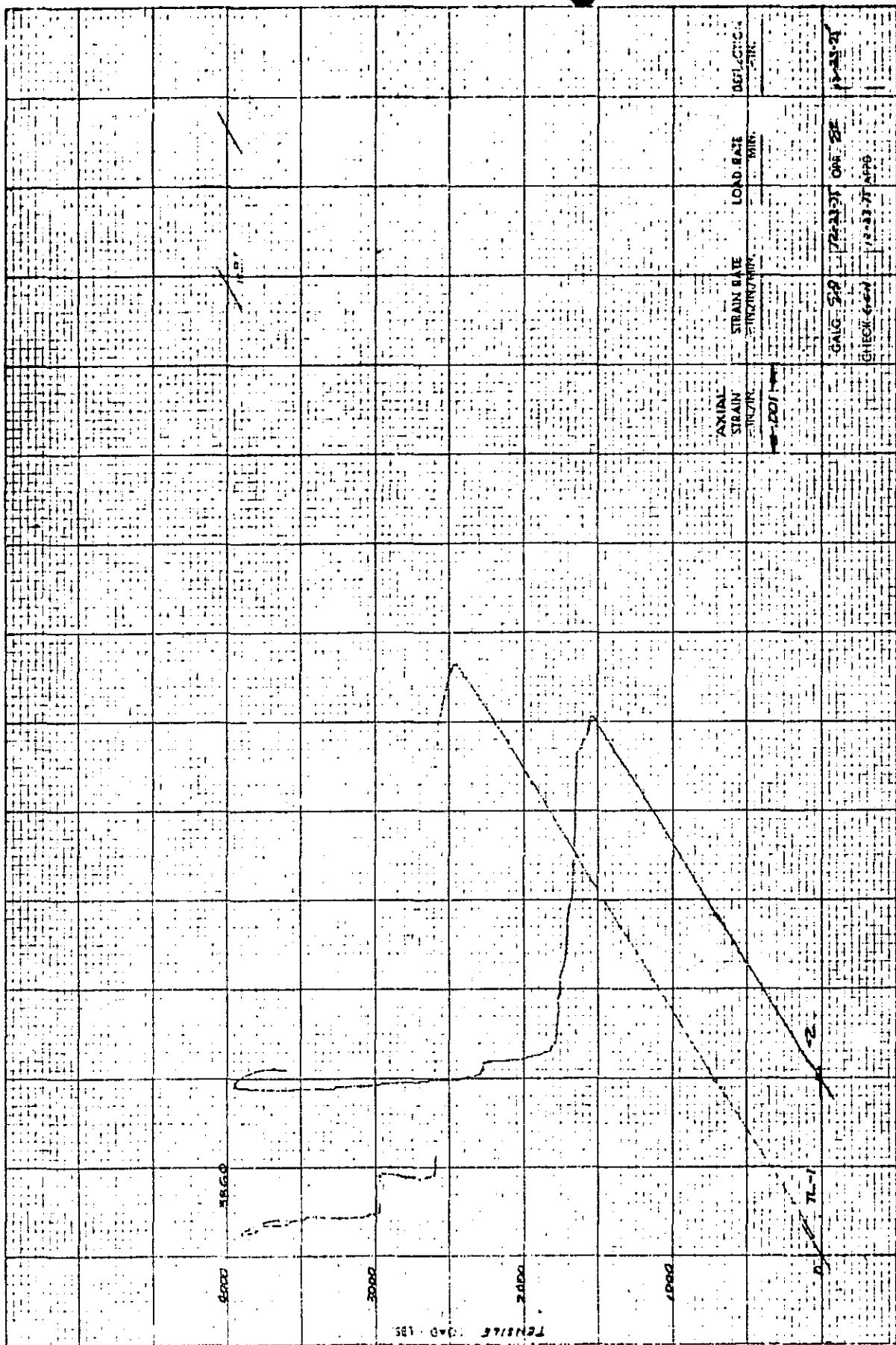
184



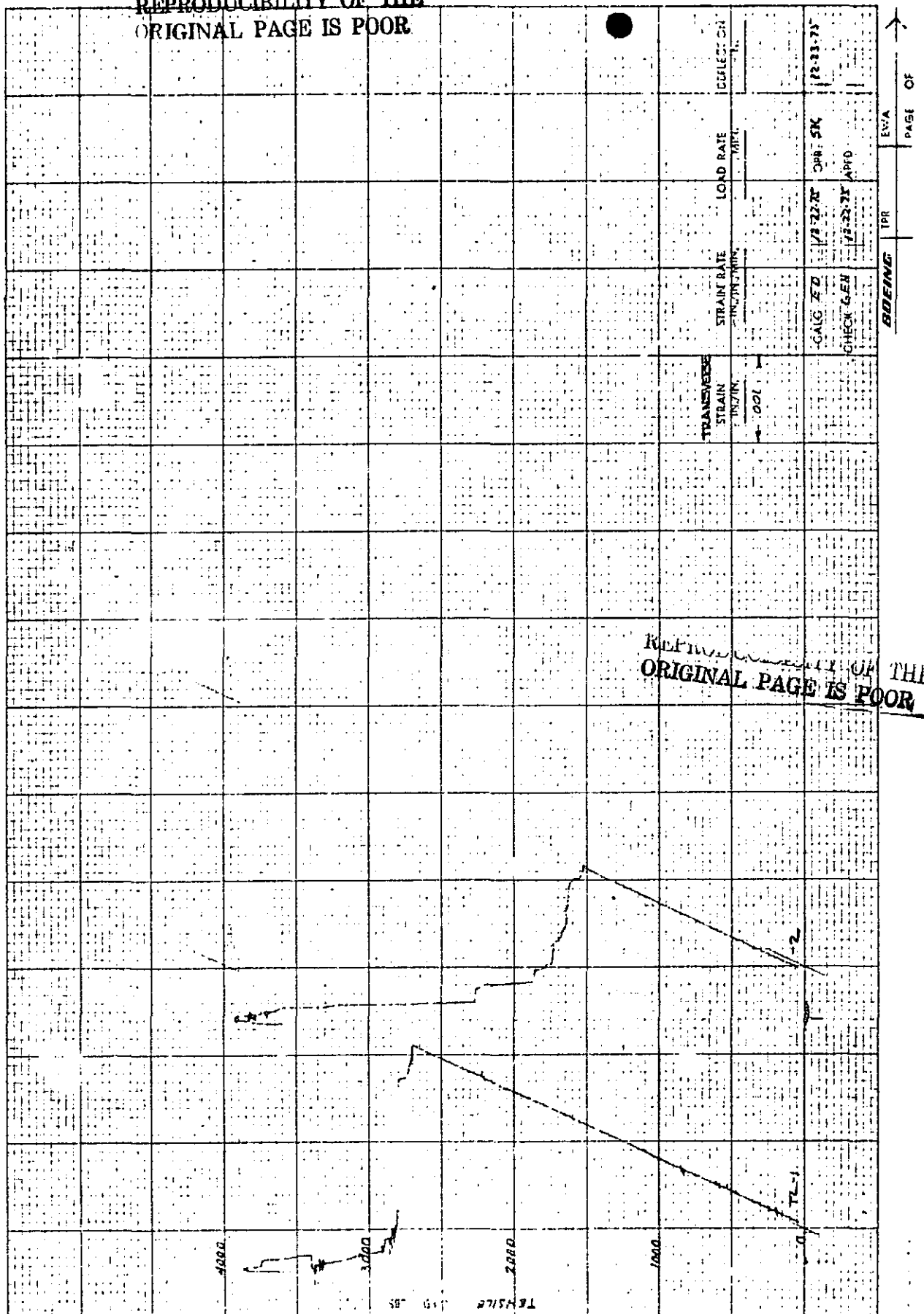




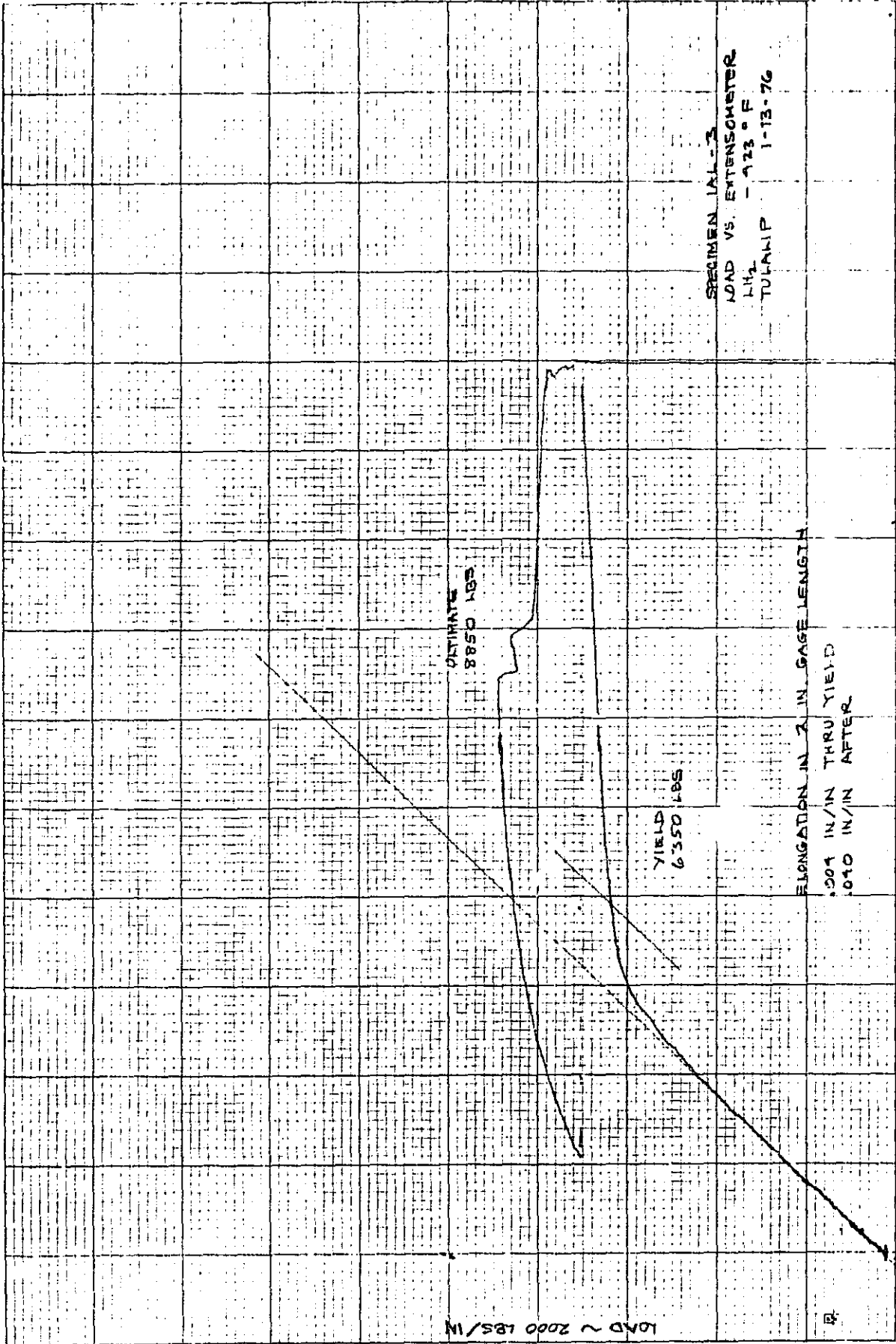


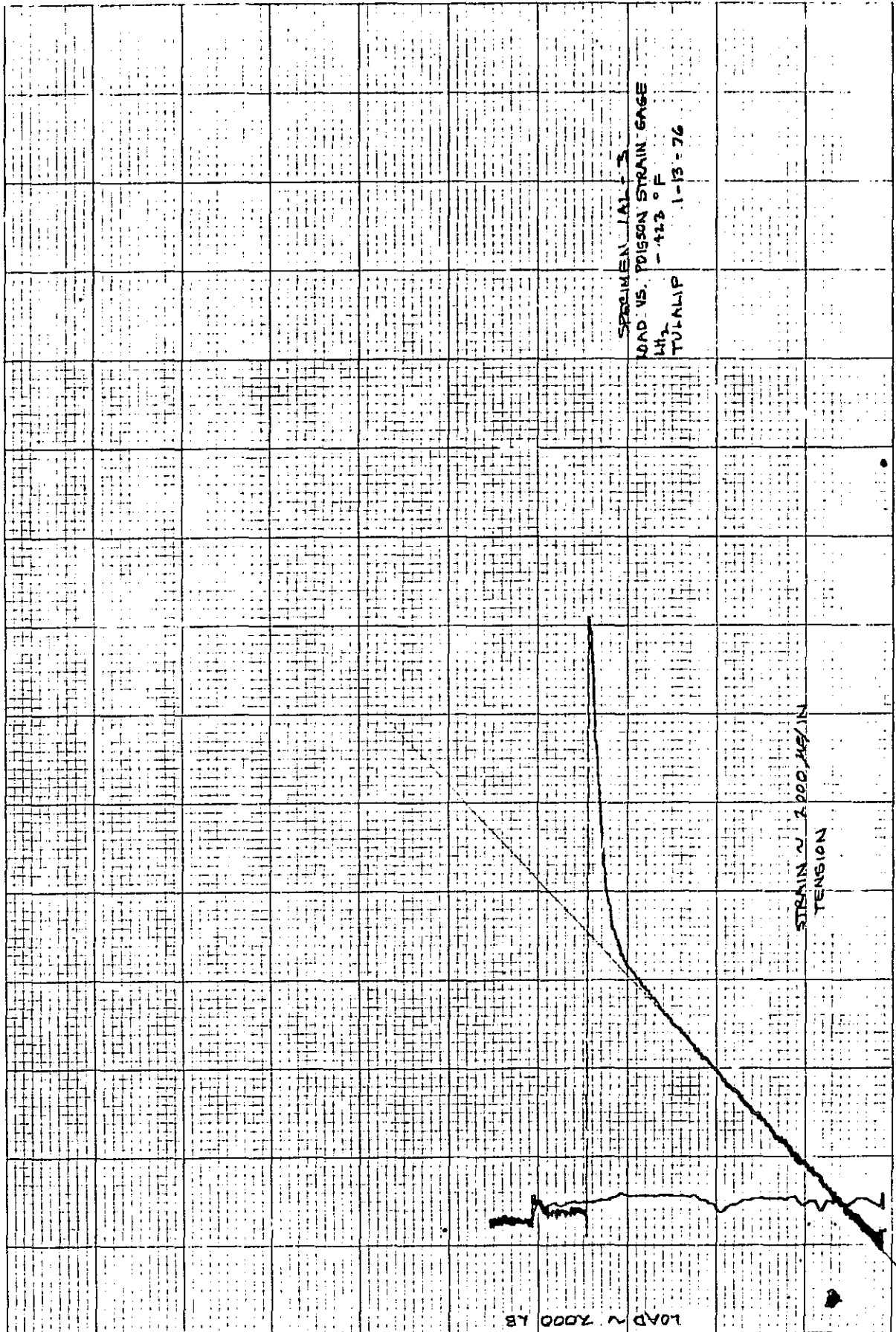


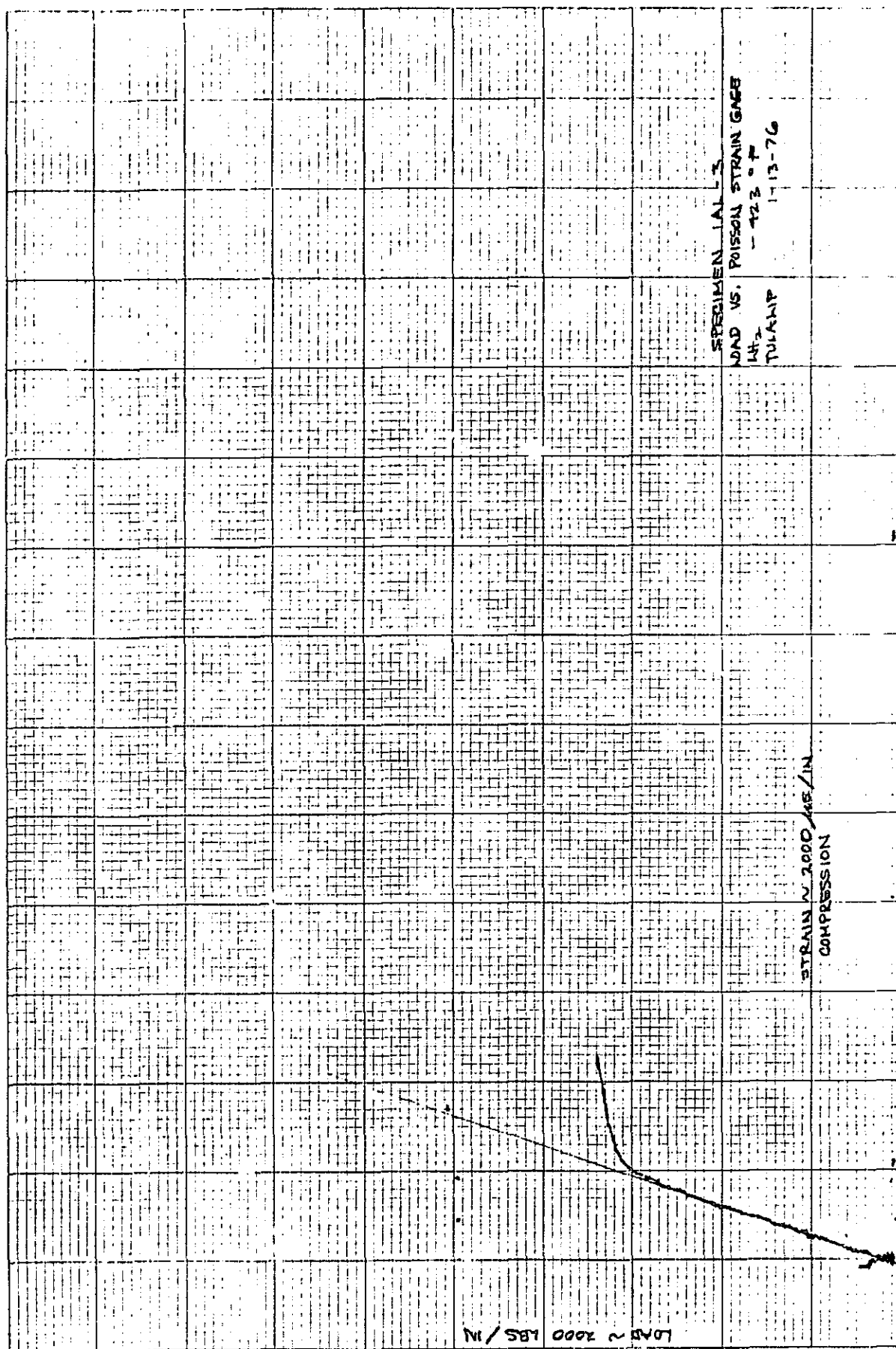
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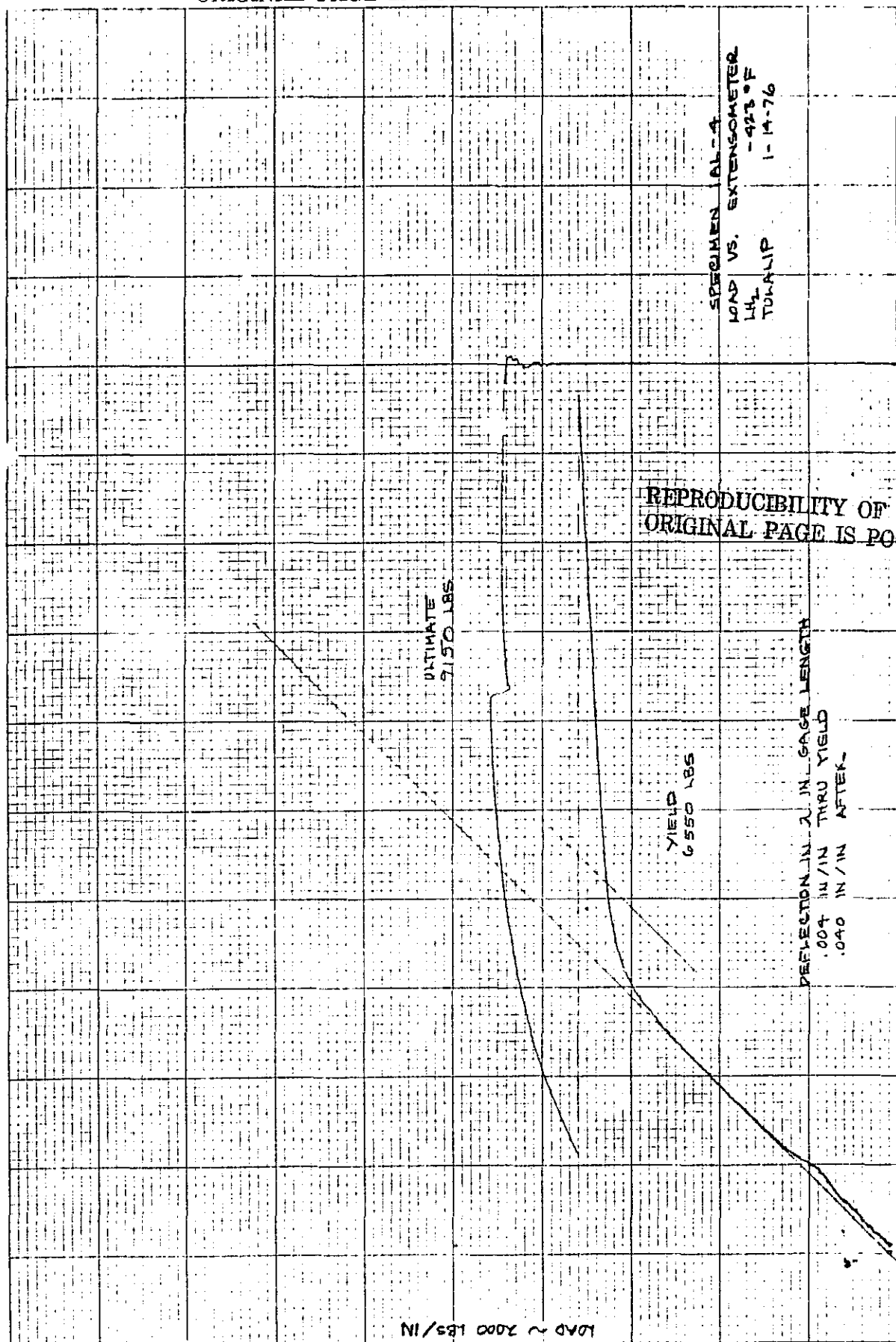
2-3



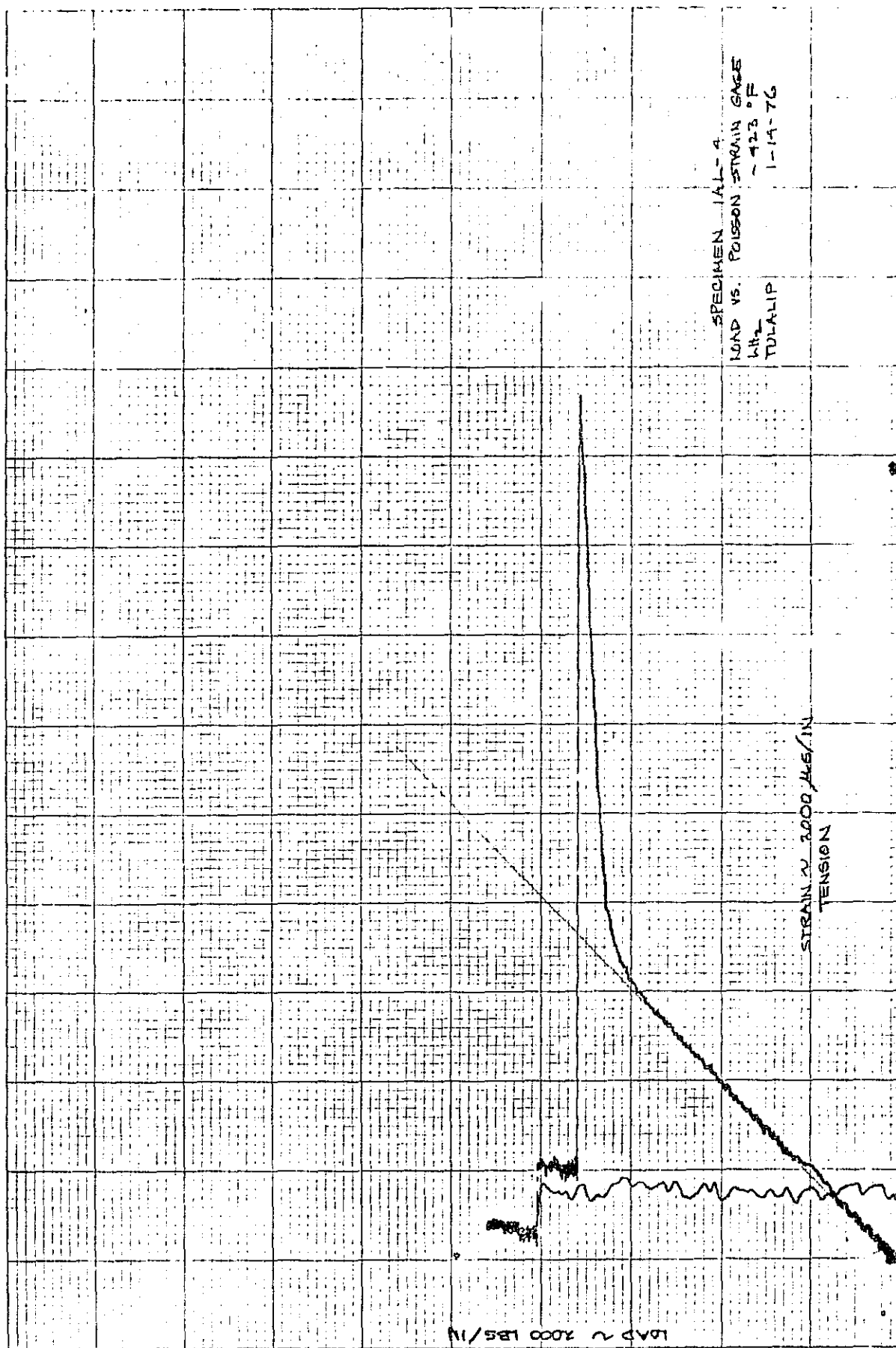




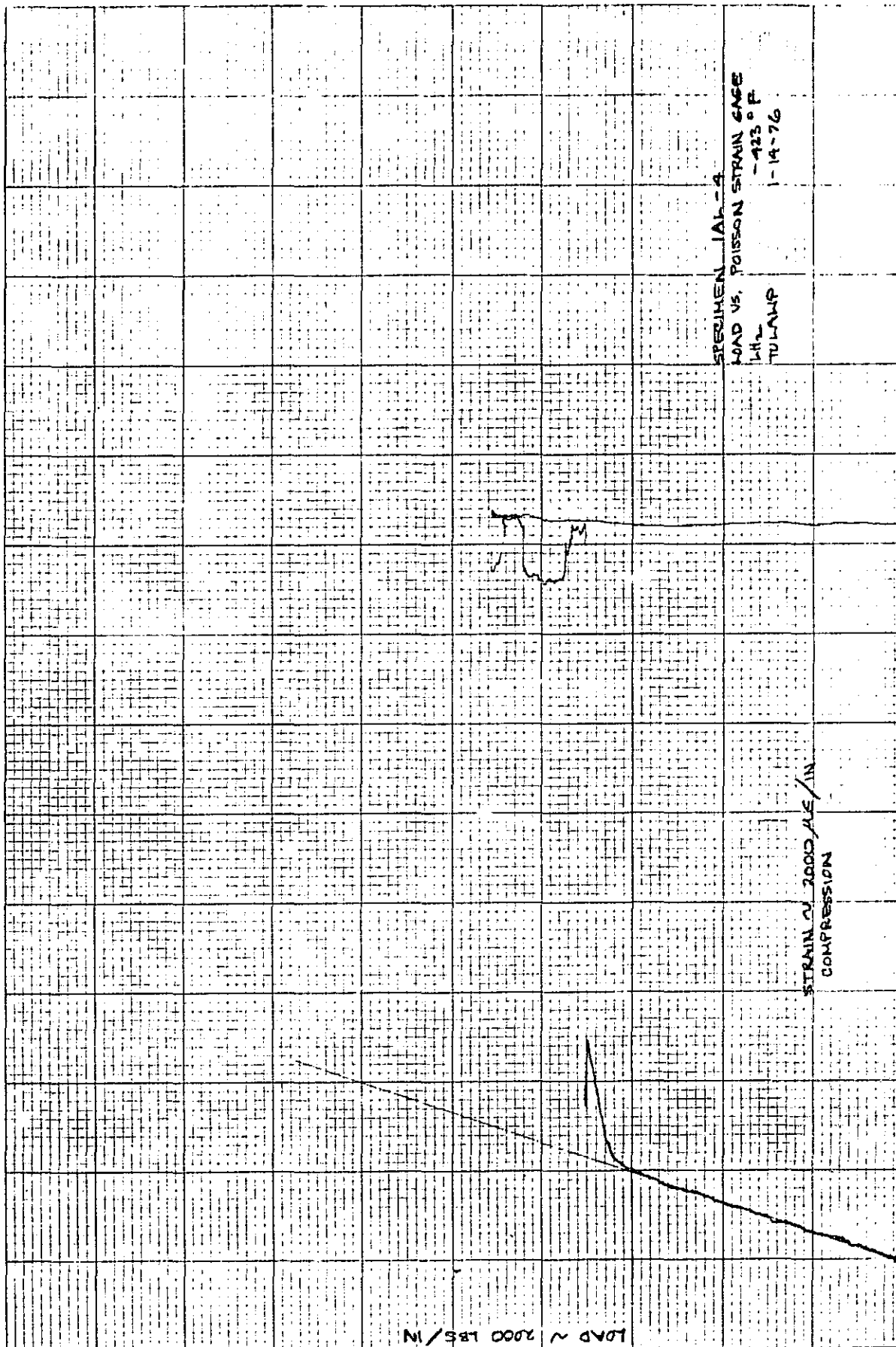
REPRODUCIBILITY OF THE
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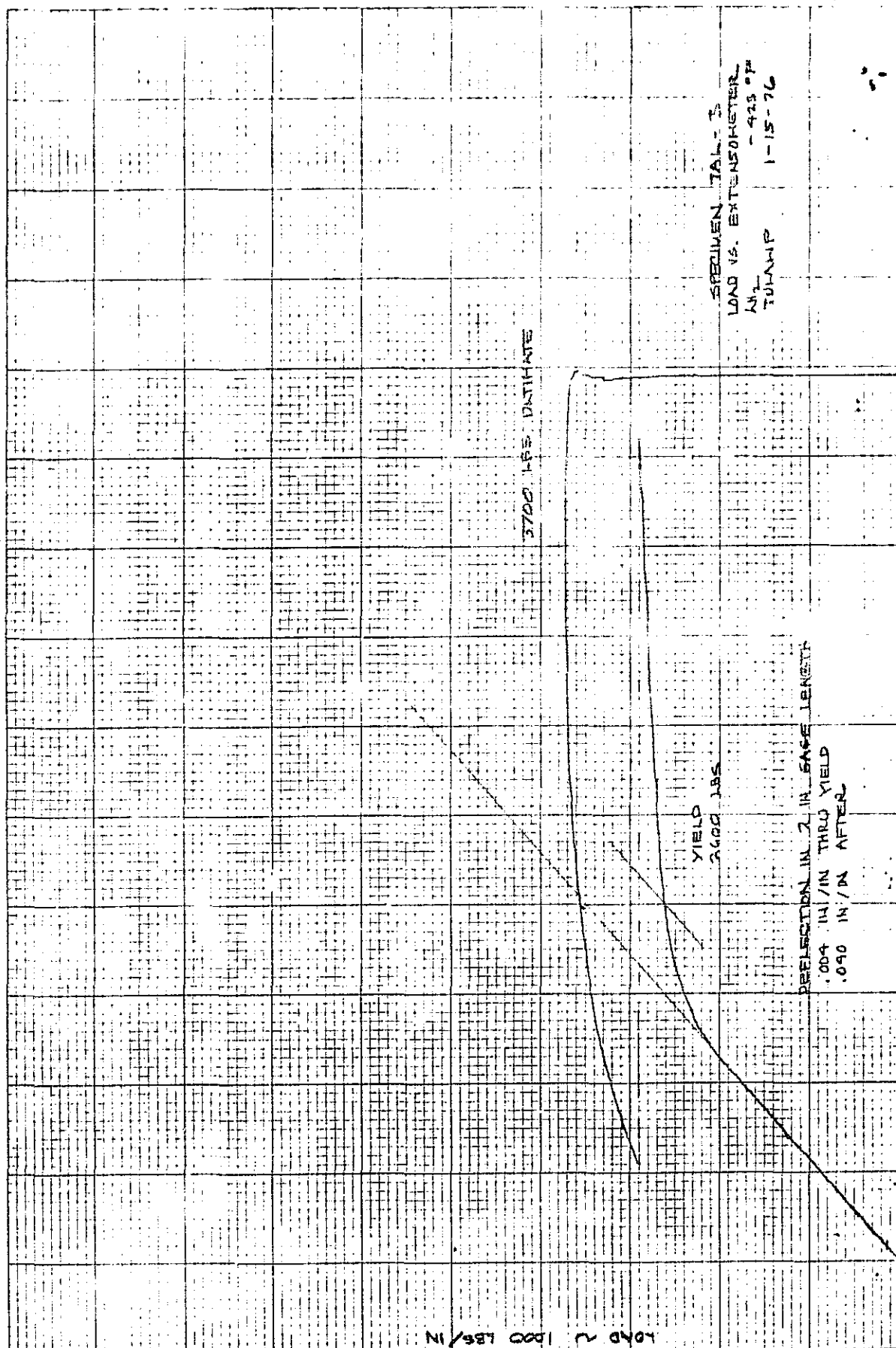


1-14-76



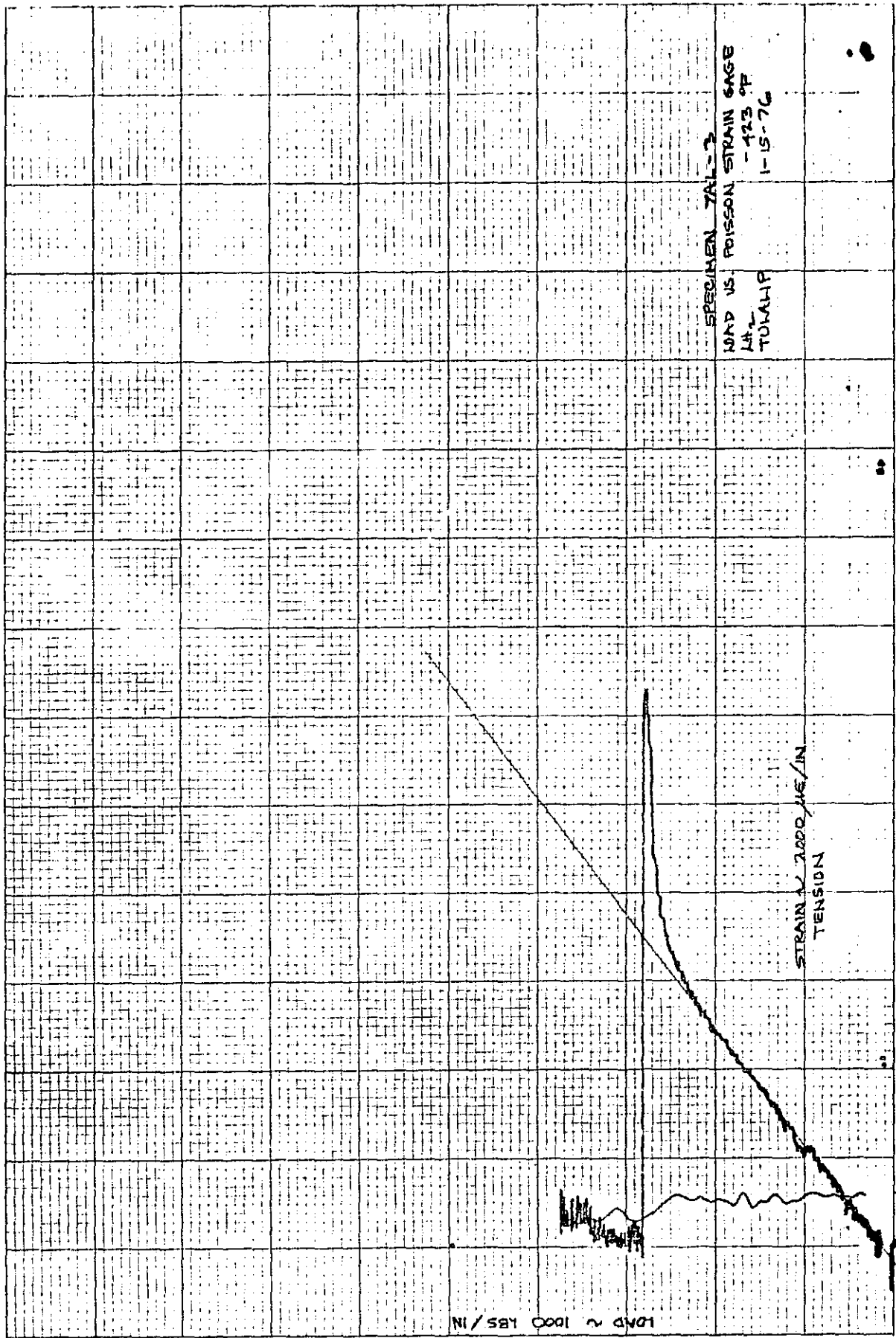
SPECIMEN 1A-4
LOAD VS. POISSON STRAIN GAGE
~ 923 °F
1-14-76
TOTALIP



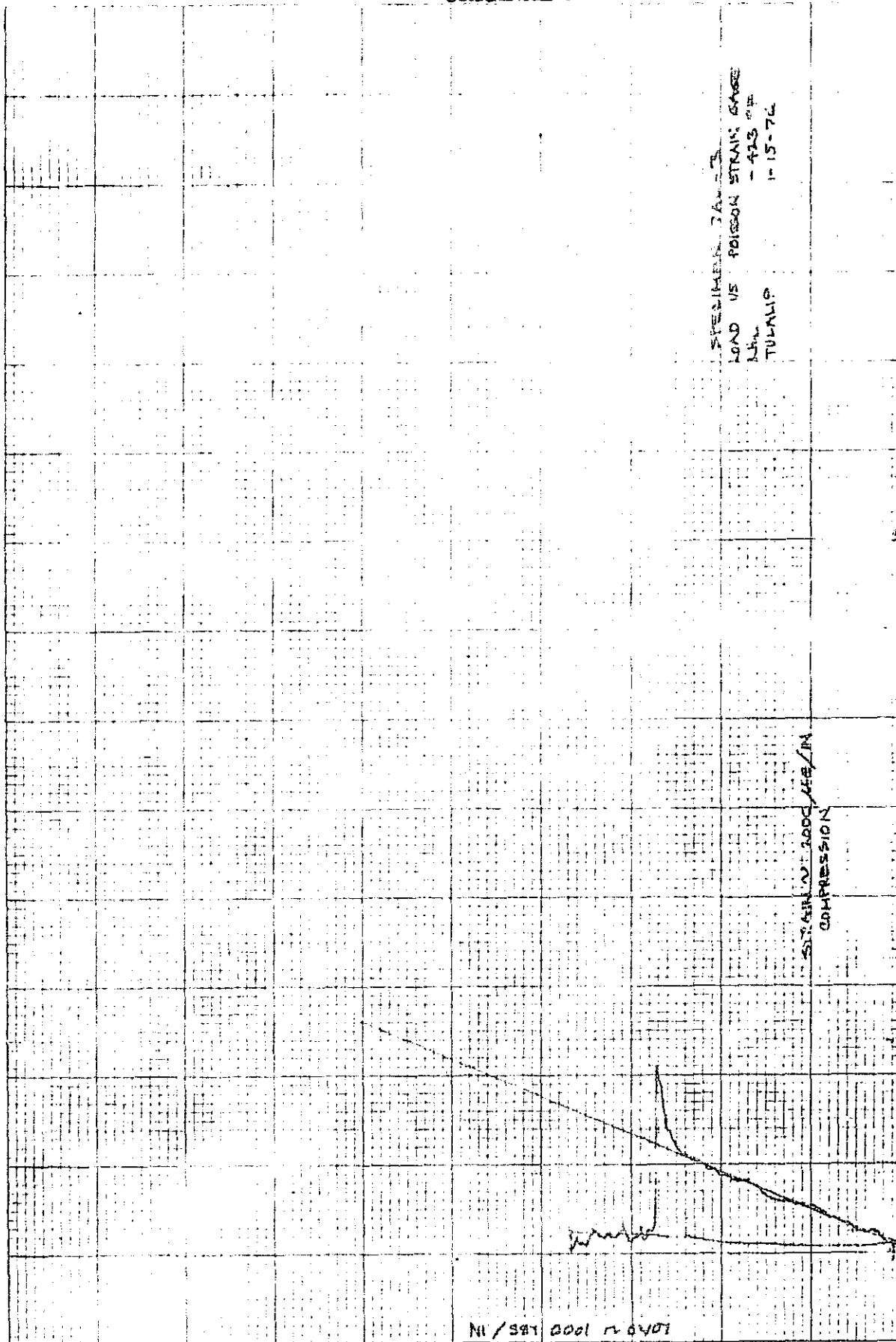


7AL-3
1-15-76

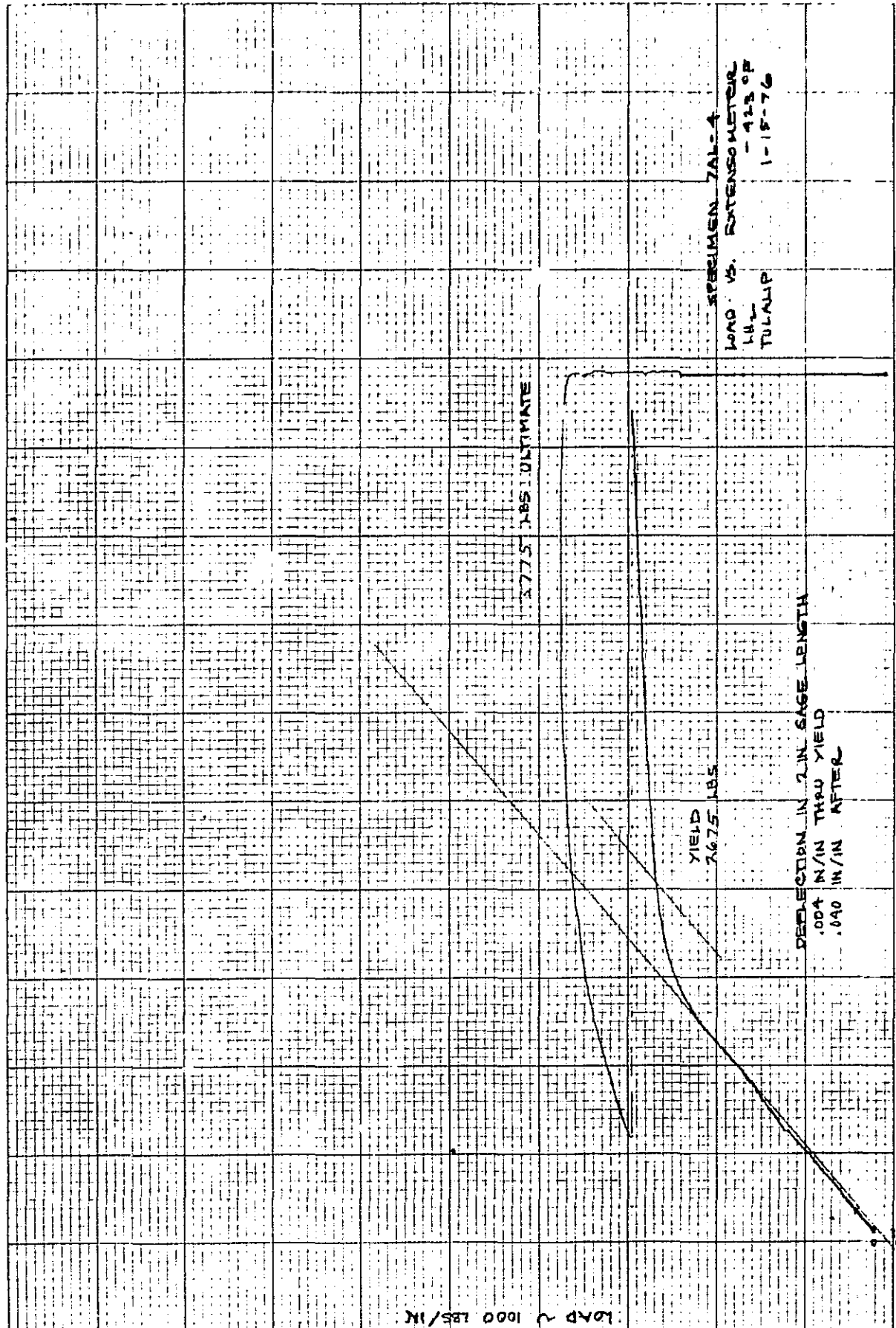
K-E INK TO THE INCH 47 0703
BUREAU OF RESEARCH



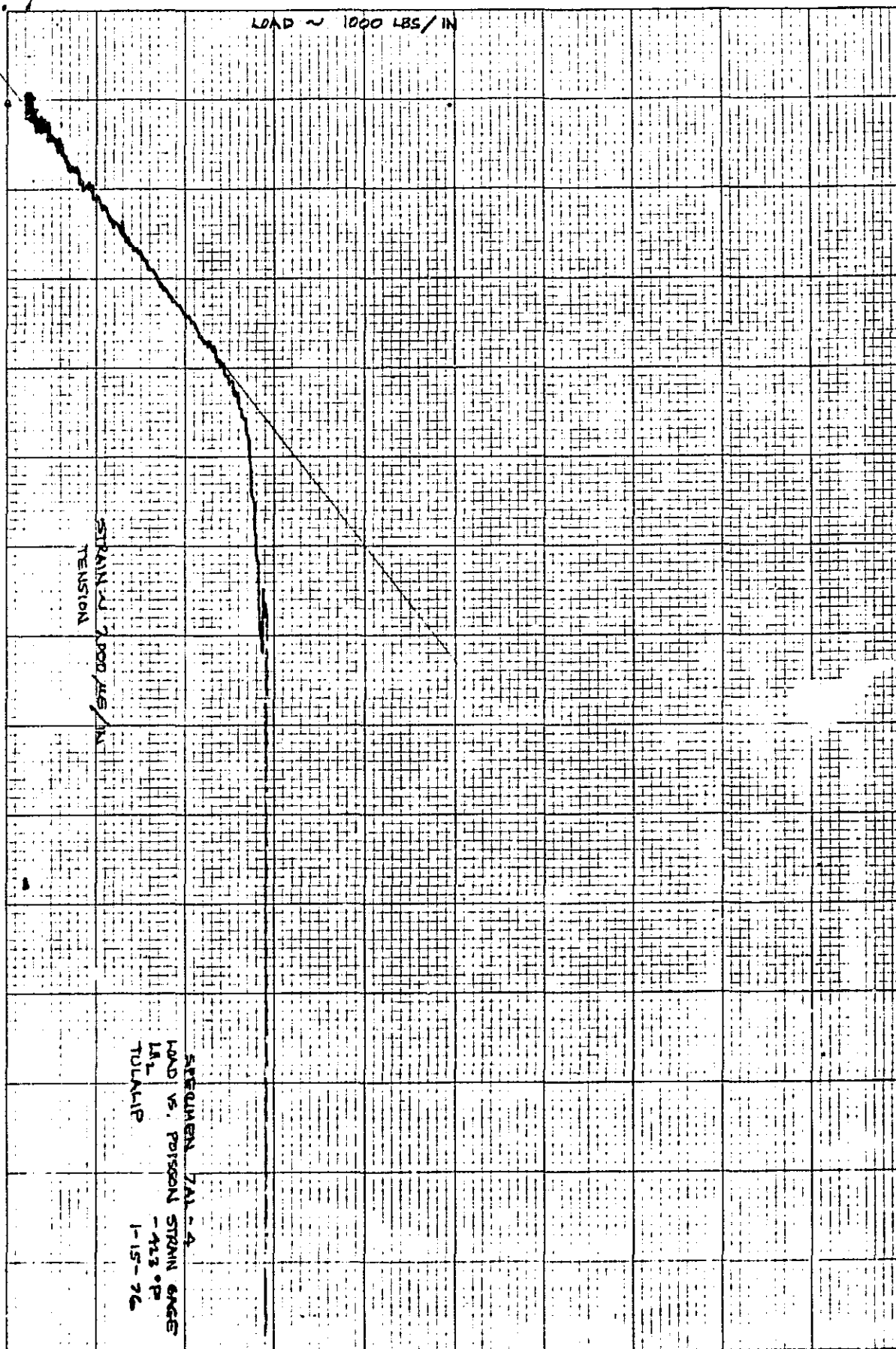
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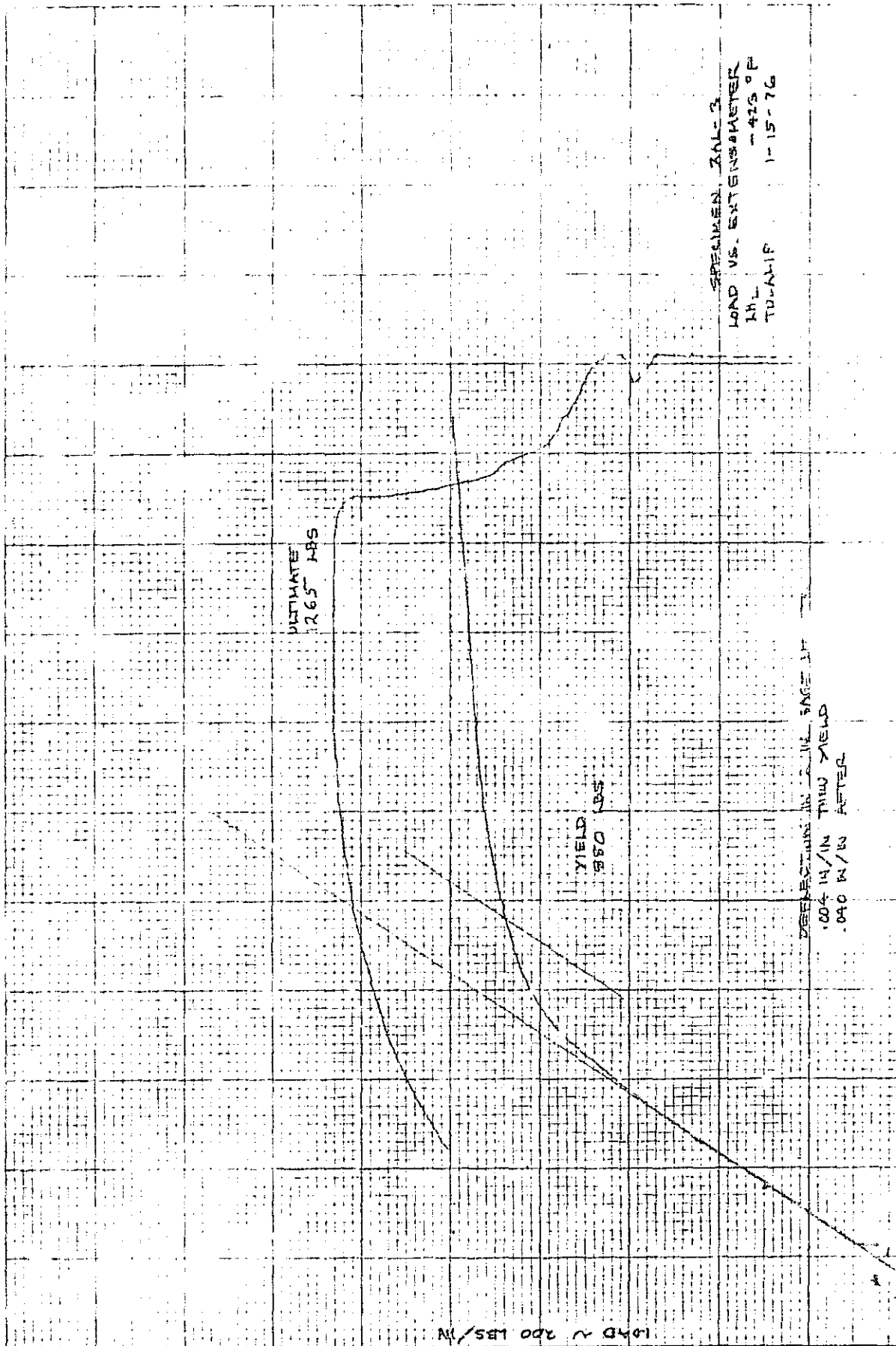


94-5
1-15-76



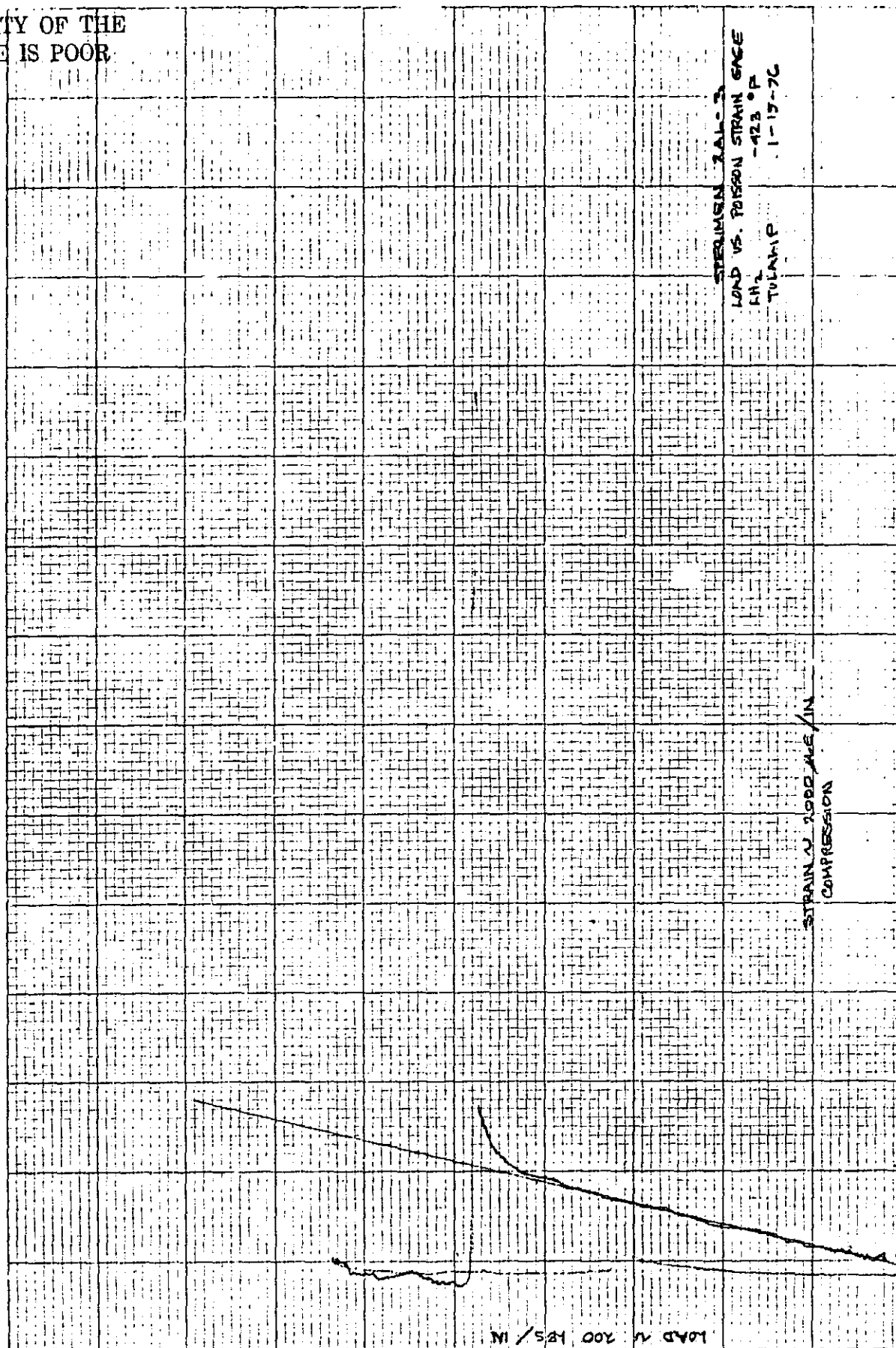


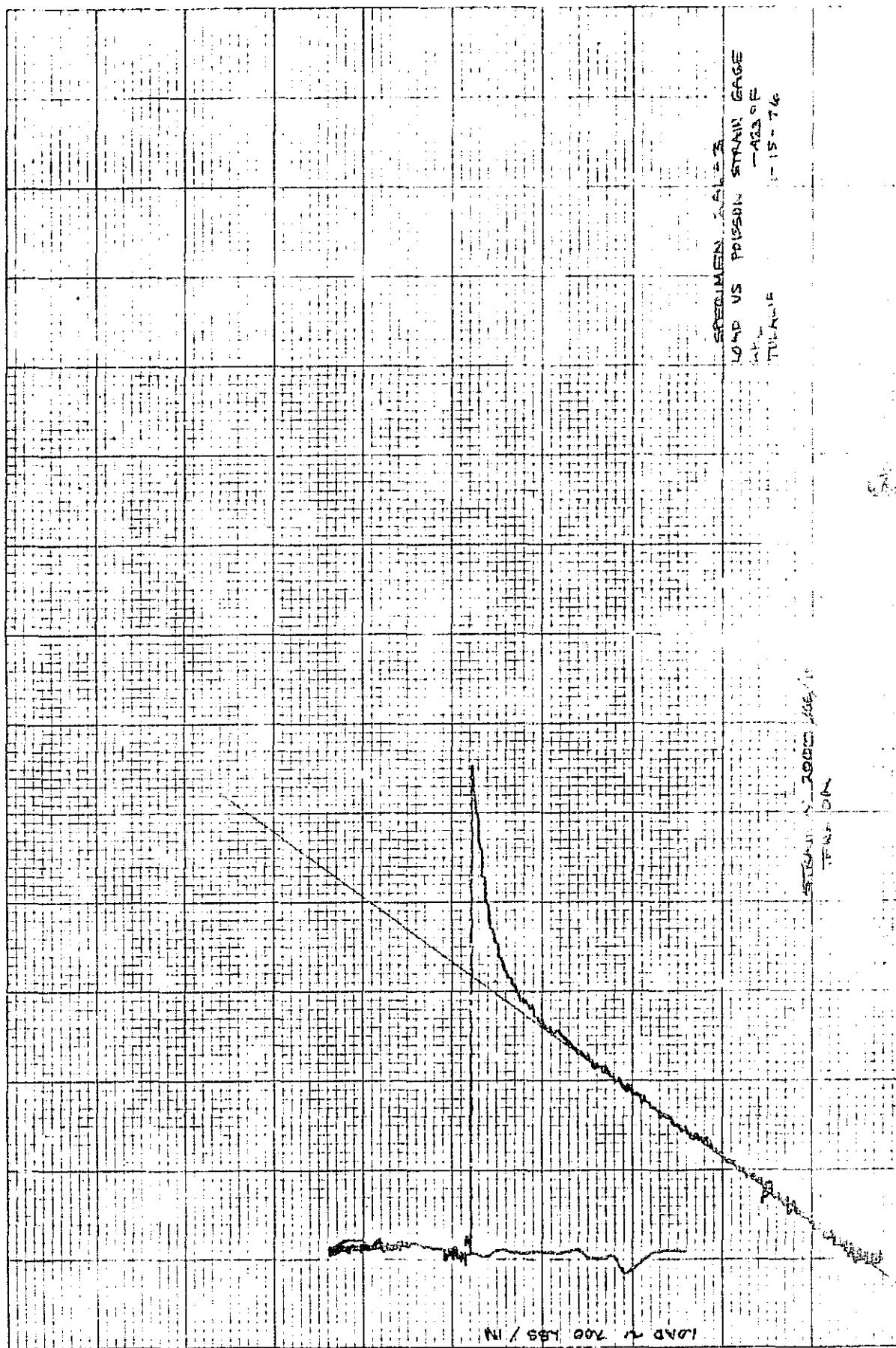




SPECIMEN 3AL-3
LOAD VS. EXTENSOMETER
LH
TUNALIP 1-15-76

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



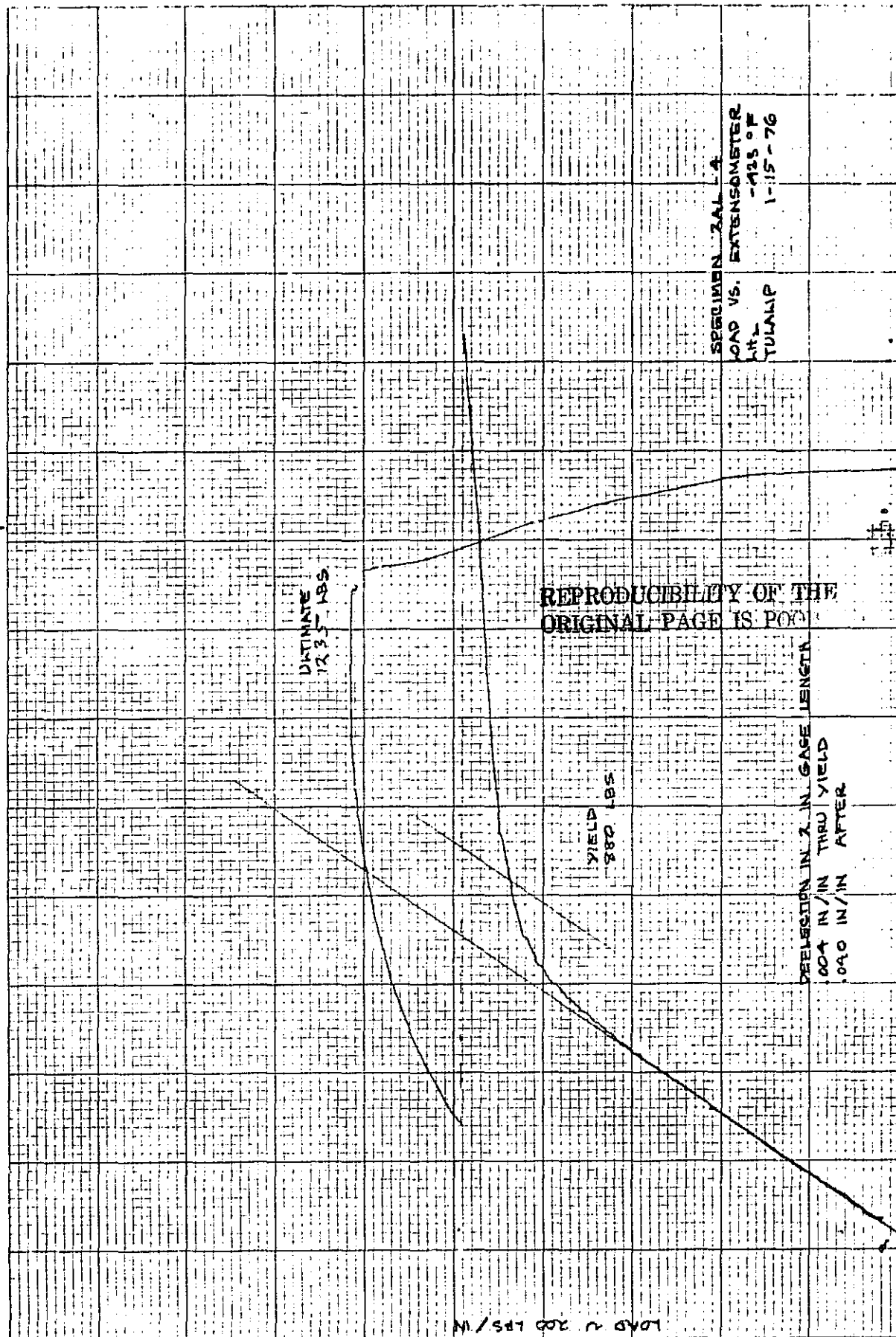


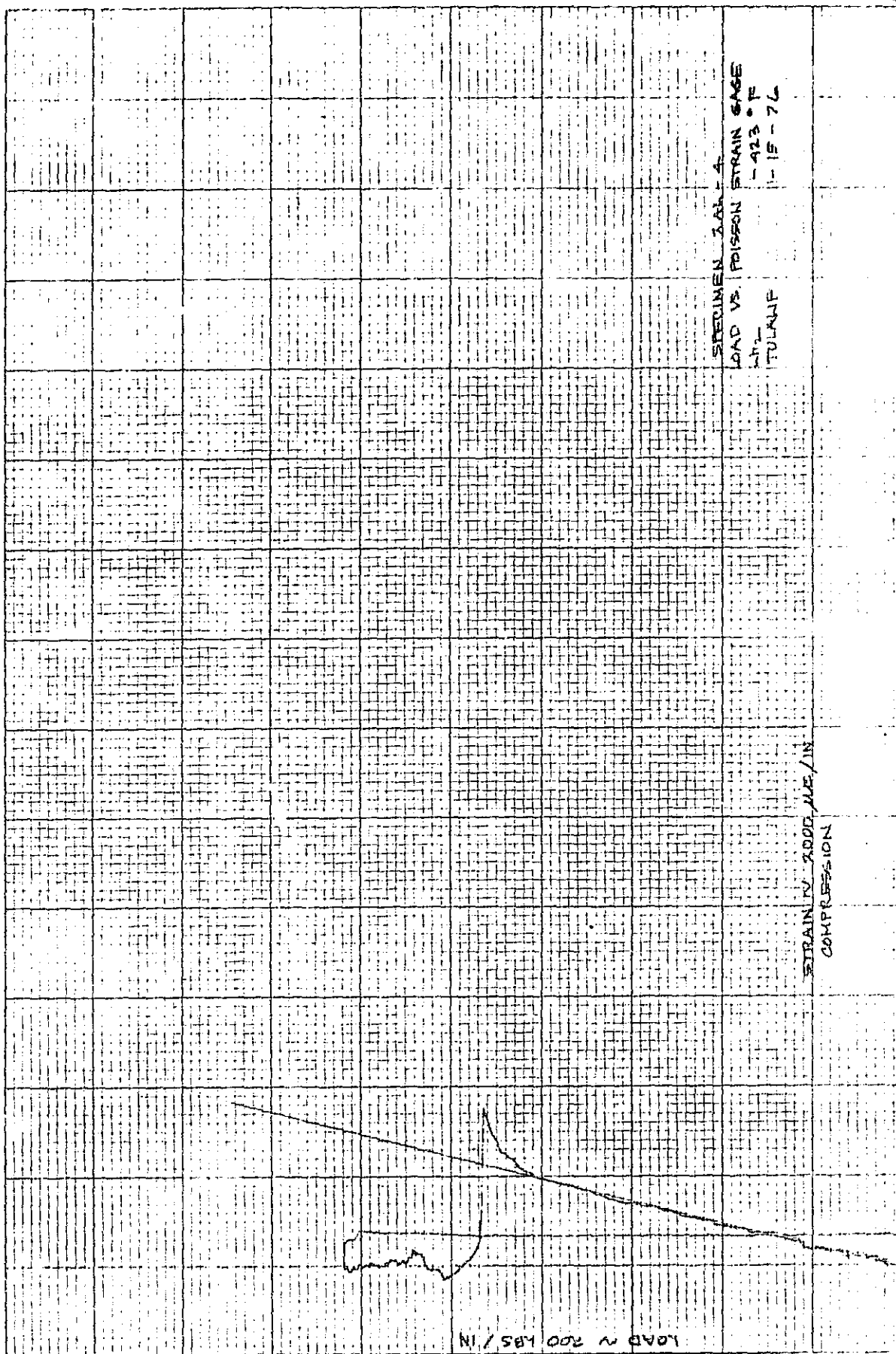
2AL-01
1-15-76

200 #/in

207

K-E 10 & 10 TO THE INCH 47 0703
RECEIVED & 0800 IN CH





2AL-4
-15-76

47 0703

609

K-E 10.2 IN TO THE RIGHT OF 2 INCHES
REMARKS & TESTED BY

